US009118479B2

(12) **United States Patent**
Ohta et al.

(10) **Patent No.: US 9,118,479 B2**
(45) **Date of Patent: Aug. 25, 2015**

(54) **MOBILE COMMUNICATION SYSTEM**

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(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 367 days.

(21) Appl. No.: **13/618,413**

(22) Filed: **Sep. 14, 2012**

(65) **Prior Publication Data**

US 2013/0012218 A1 Jan. 10, 2013

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2010/054360, filed on Mar. 15, 2010.

(51) **Int. Cl.**

H04W 72/00	(2009.01)
H04L 1/18	(2006.01)
H04W 72/12	(2009.01)
H04L 1/00	(2006.01)
H04W 84/04	(2009.01)
H04W 88/08	(2009.01)

(52) **U.S. Cl.**

CPC ***H04L 1/1887*** (2013.01); ***H04W 72/12*** (2013.01); *H04L 2001/0097* (2013.01); *H04W 84/047* (2013.01); *H04W 88/08* (2013.01)

(58) **Field of Classification Search**

CPC H04L 1/1887; H04L 2001/0097; H04W 72/12; H04W 88/08; H04W 87/047

USPC 455/450–452.2, 11.1, 7, 502; 370/315, 370/350, 328–329

See application file for complete search history.

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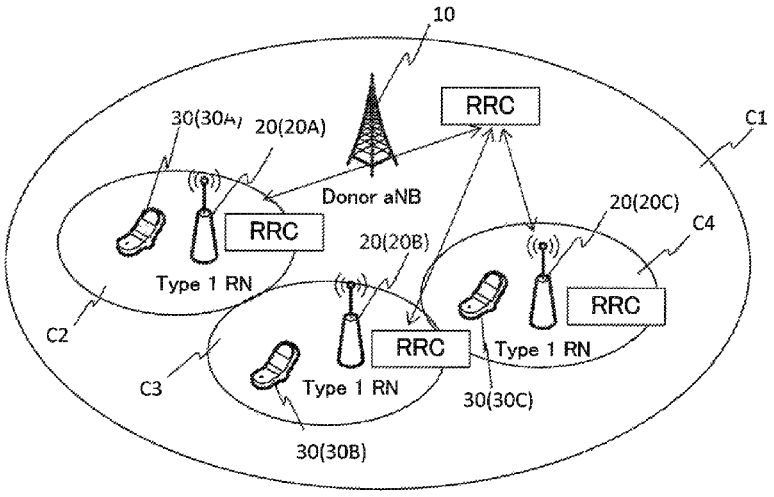
(57) **ABSTRACT**

A mobile communication system comprises a base station and a relay station to relay data transmitted/received between the base station and a mobile station. The base station includes a first scheduler to perform scheduling of initial transmission of the data transmitted/received between the base station and the mobile station via the relay station, and a first manager to manage predetermined wireless resources which are periodically used, as wireless resources used for the initial transmission of the data. The relay station includes a second scheduler configured to perform scheduling of transmission of a message for confirming necessity of retransmission of the data and retransmission of the data and a second manager configured to manage wireless resources used for the transmission of the message and the retransmission of the data.

12 Claims, 21 Drawing Sheets



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3GPP TR 36.913 V8.0.1 (Mar. 2009); 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; "Requirements for further advancements for Evolved Universal Terrestrial Radio Access (E-UTRA) (LTE-Advanced) (Release 8)"; Mar. 2009.

International search report issued for corresponding International Patent Application No. PCT/JP2010/054360 mailed May 25, 2010.

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FIG. 1

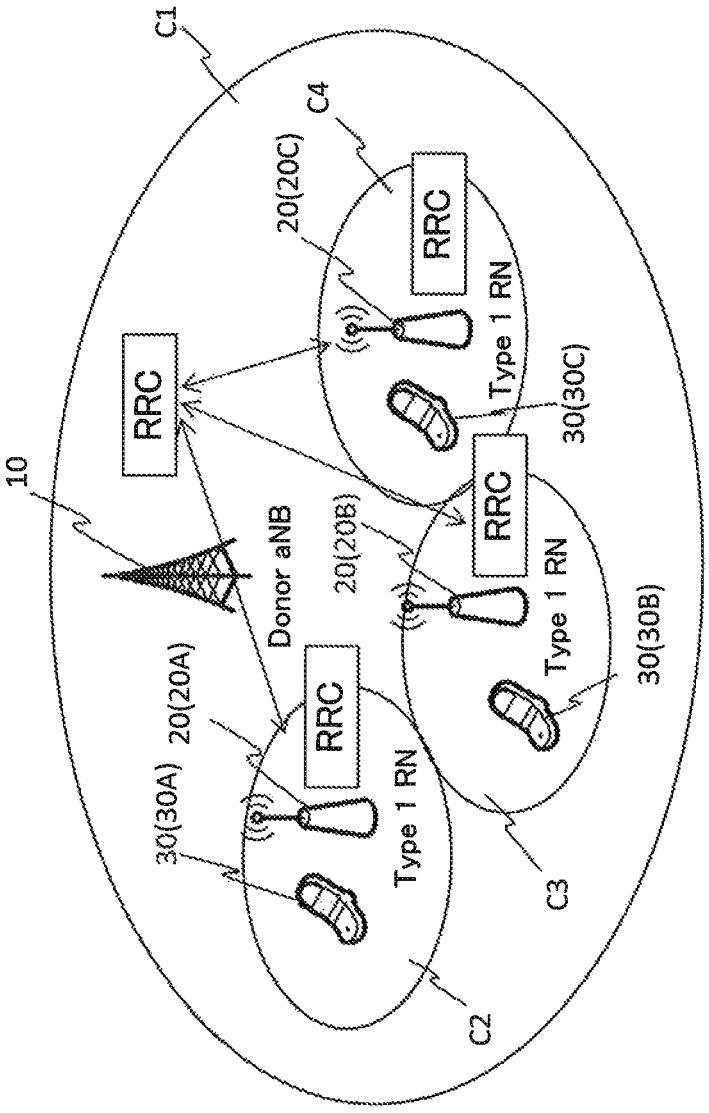

C1
C4
20(20C)
RRC
Type 1 RN
30(30C)
RRC
10
RRC
Donor aNB
20(20B)
RRC
Type 1 RN
30(30B)
20(20A)
30(30A)
Type 1 RN
C3
C2

FIG. 2

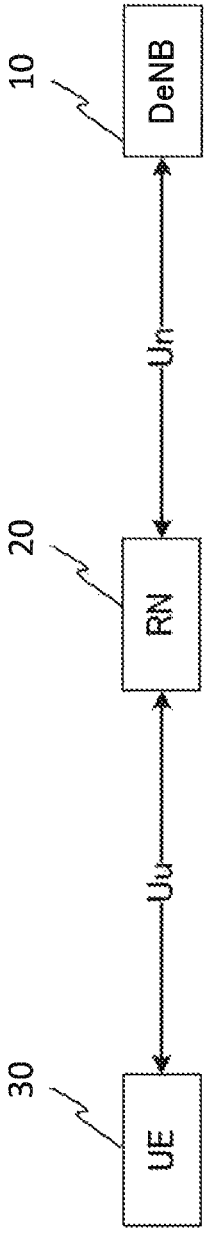


FIG. 3

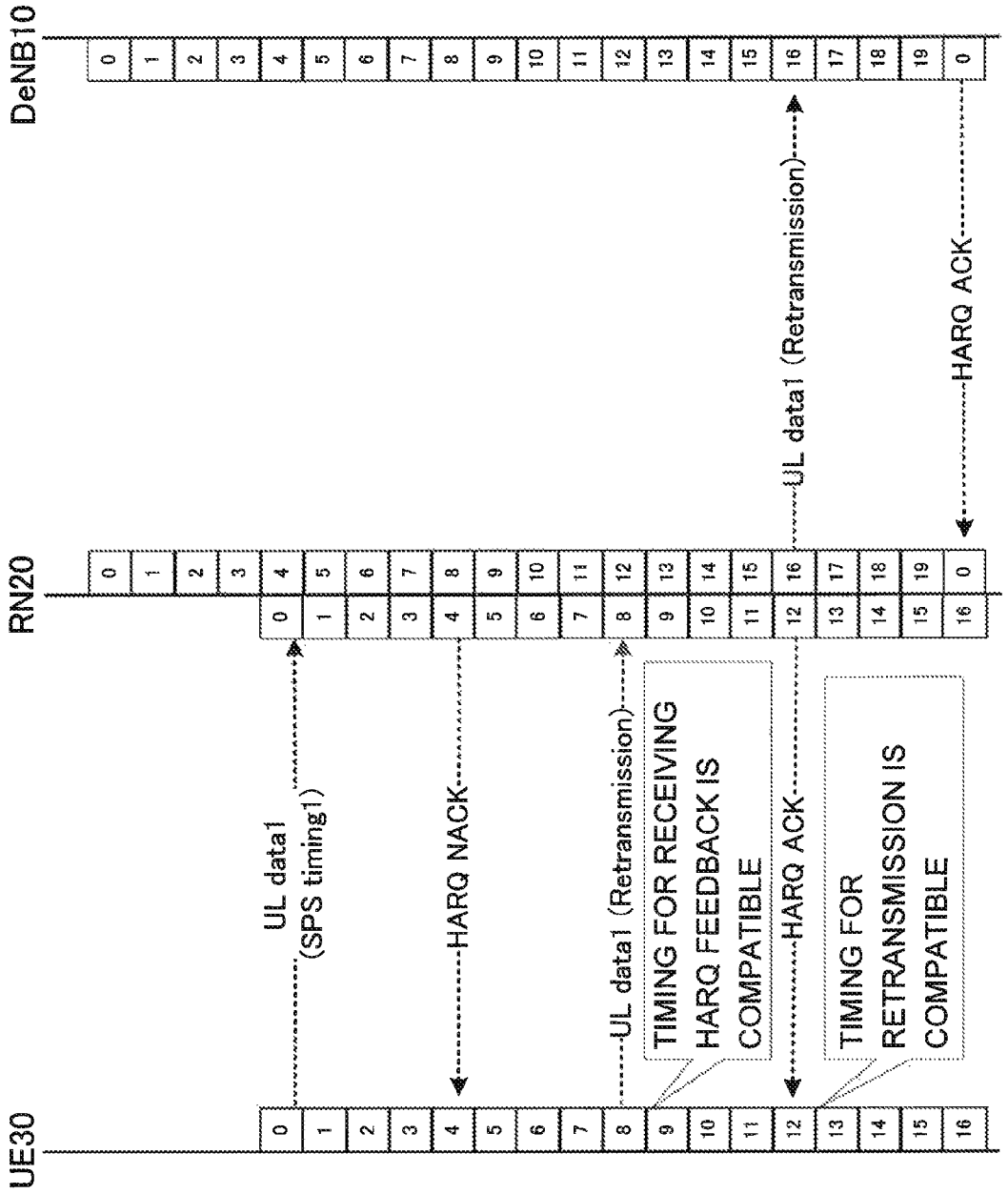

DeNB10
RN20
UE30
UL data1
(SPS timing1)
HARQ NACK
UL data1 (Retransmission)
TIMING FOR RECEIVING HARQ FEEDBACK IS COMPATIBLE
HARQ ACK
TIMING FOR RETRANSMISSION IS COMPATIBLE
UL data1 (Retransmission)
HARQ ACK

FIG. 4

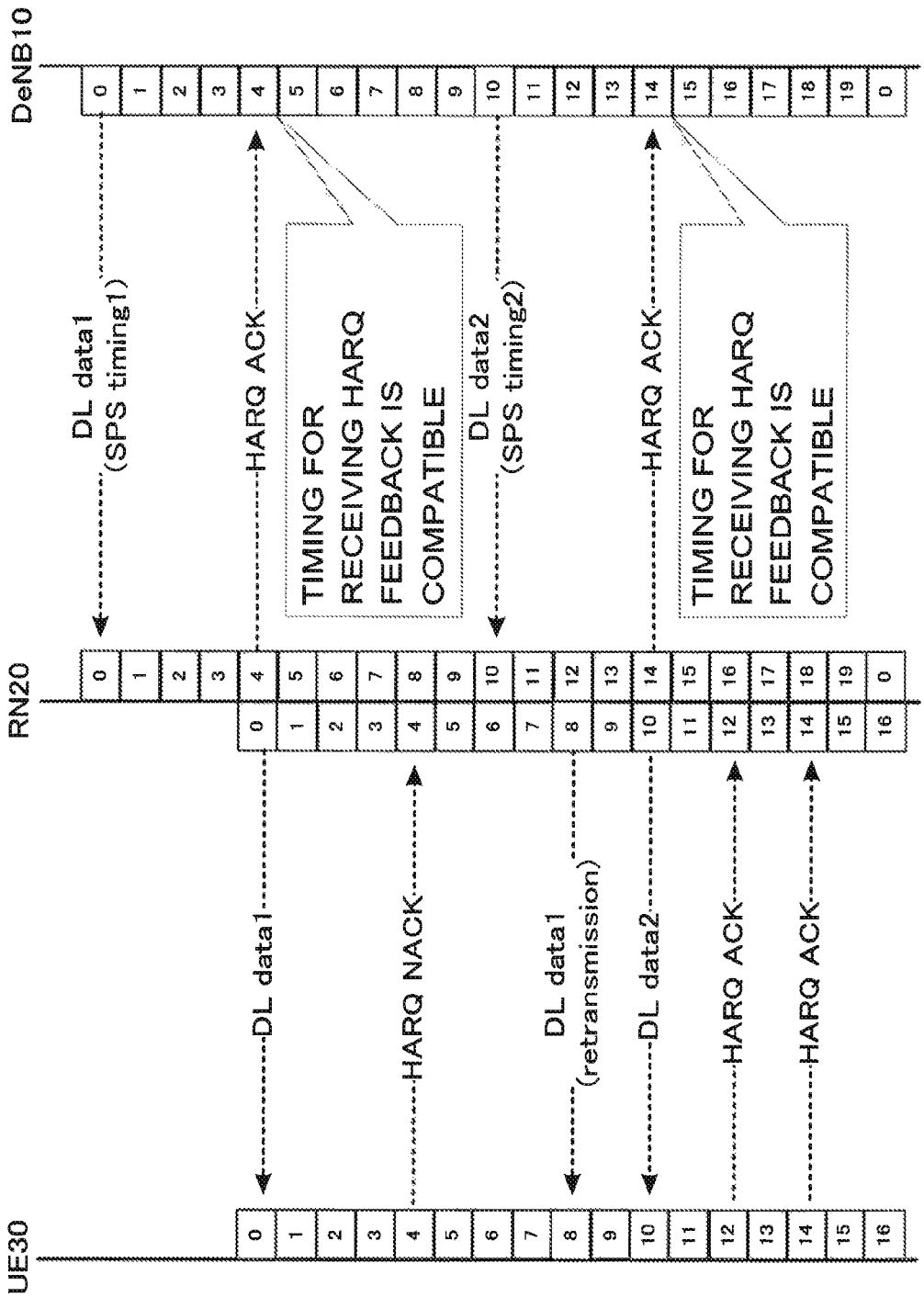

DeNB10
RN20
UE30
DL data1 (SPS timing1)
HARQ ACK
TIMING FOR RECEIVING HARQ FEEDBACK IS COMPATIBLE
DL data2 (SPS timing2)
HARQ ACK
TIMING FOR RECEIVING HARQ FEEDBACK IS COMPATIBLE
DL data1
HARQ NACK
DL data1 (retransmission)
DL data2
HARQ ACK
HARQ ACK

FIG. 5

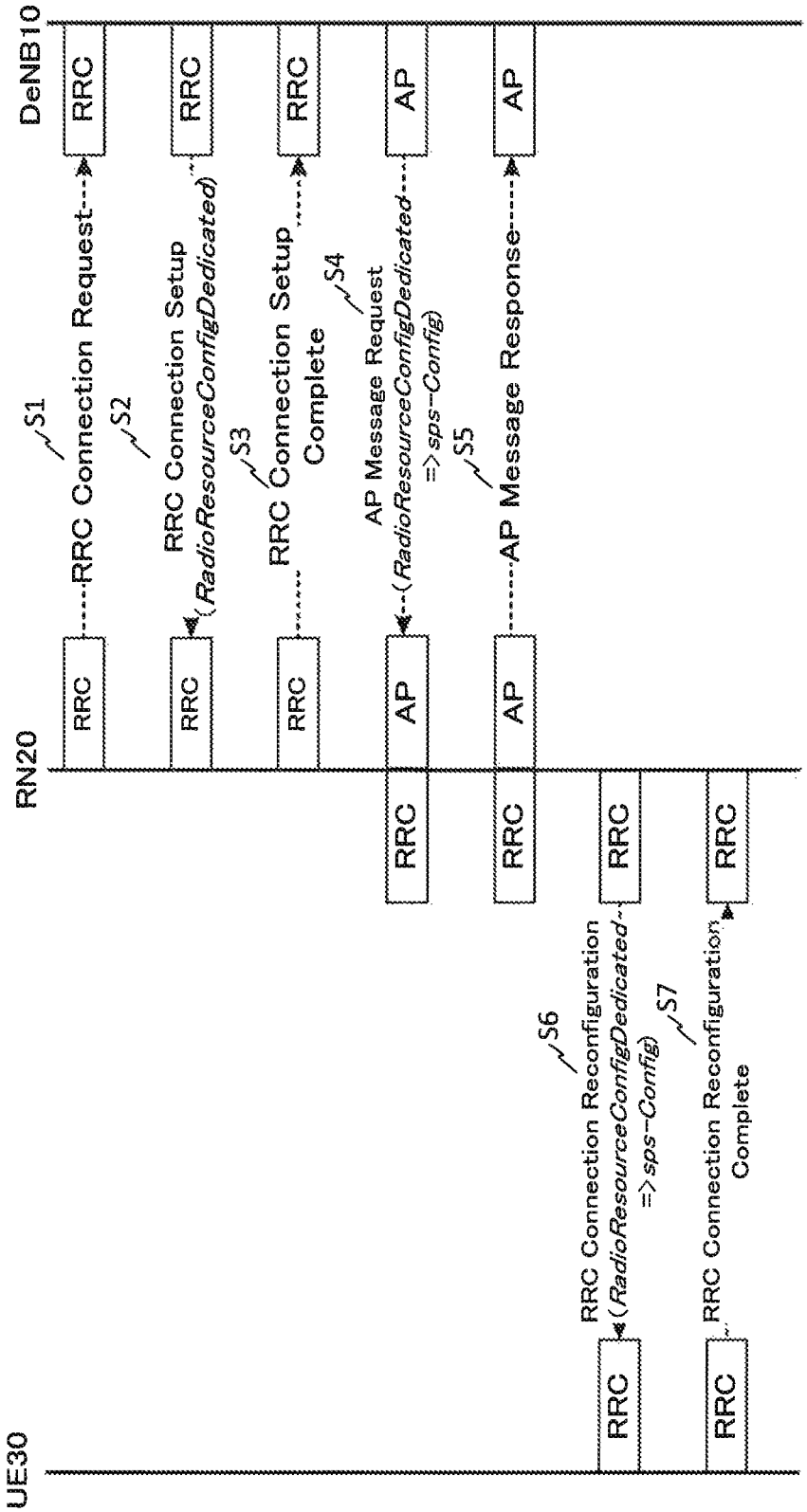

UE30
RN20
DeNB10
RRC
AP
S1
RRC Connection Request
S2
RRC Connection Setup
(RadioResourceConfigDedicated)
S3
RRC Connection Setup Complete
S4
AP Message Request
(RadioResourceConfigDedicated
=>sps-Config)
S5
AP Message Response
S6
RRC Connection Reconfiguration
(RadioResourceConfigDedicated
=>sps-Config)
S7
RRC Connection Reconfiguration Complete

FIG. 6

RadioResourceConfigDedicated information element

```
---ASN1START

RadioResourceConfigDedicated : : =      SEQUENCE {
     srb-ToAddModList                   SRB-ToAddModList     OPTIONAL,     -- Cond HO-Conn
     drb-ToAddModList                   DRB-ToAddModList     OPTIONAL,     -- Cond HO-
toEUTRA
     drb-ToReleaseList                  DRB-ToReleaseList    OPTIONAL,     -- Need ON
     mac-Mainconfig                        CHOICE {
               explicitValue                  MAC-MainConfig,
               defaultValue                   NULL
     }         OPTIONAL,
toEUTRA2
     sps-Config                    SPS-Config                OPTIONAL, -- Need ON
     physicalConfigDedicated       PhysicalConfigDedicated   OPTIONAL, -- Need ON
     ...
}
SRB-ToAddModList : : =     SEQUENCE (SIZE (1..2)) OF SRB-ToAddMod
SRB-ToAddMod : : =         SEQUENCE {
     srb-Identity                       INTEGER (1..2),
     rlc-Config                         CHOICE {
               explicitValue                RLC-Config,
               defaultValue                 NULL
     }         OPTIONAL,                                          -- Cond Setup
     logicalChannelConfig               CHOICE {
               explicitValue                LogicalChannelConfig,
               defaultValue                 NULL
  }            OPTIONAL,                                          -- Cond Setup
     ...
}
DRB-ToAddModList : : =       SEQUENCE (SIZE (1..maxDRB)) OF DRB-ToAddMod

DRB-ToAddMod : : =         SEQUENCE {
     eps-BearerIdentity        INTEGER (0..15)     OPTIONAL,        -- Cond DRB-Setup
     drb-Identity              DRB-Identity,
     pdcp-Config               PDCP-Config         OPTIONAL,        -- Cond PDCP
     rlc-Config                RLC-Config          OPTIONAL,        -- Cond Setup
     logicalChannelIdentity    INTEGER (3..10)     OPTIONAL,        -- Cond DRB-Setup
     logicalChannelConfig      LogicalChannelConfig OPTIONAL,       --Cond SetUP
   ...
}
DRB-ToReleaseList : : =      SEQUENCE (SIZE (1..maxDRB)) OF DRB-Identity

--ASN1STOP
```

FIG. 7

SPS-Config information element

```
---ASN1START

SPS-Config : : =          SEQUENCE {
     semiPersistDSchedC-RNTI     C-RNTI            OPTIONAL,       -- Need OR
     sps-ConfigDL                SPS-ConfigDL      OPTIONAL,       -- Need ON
     sps-ConfigUL                SPS-ConfigUL      OPTIONAL        -- Need ON
}
SPS-ConfigDL  : : =   CHOICE {
      release                     NULL,
      setup                       SEQUENCE  {
           semiPersistSchedIntervalDL          ENUMERATED {
                                                  sf10, sf20, sf32, sf40, sf64, sf80,
                                                  sf128, sf160, sf320, sf640, spare6,
                                                  spare5, spare4, spare3, spare2,
                                                  spare1},
           numberOfConfSPS-Processes           INTEGER (1..8),
           n1-PUCCH-AN-PersistentList          N1-PUCCH-AN-PersistentList,
           ...
      }
}
SPS-ConfigUL   : : =      CHOICE {
     release                      NULL,
     setup                        SEQUENCE  {
           semiPersistSchedIntervalUL          ENUMERATED  {
                                                  sf10, sf20, sf32, sf40, sf64, sf80,
                                                  sf128, sf160, sf320, sf640, spare6,
                                                  spare5, spare4, spare3, spare2,
                                                  spare1},
           implicitReleaseAfter                ENUMERATED  {e2, e3, e4, e8},
           p0-Persistent                       SEQUENCE  {
                p0-Nominal PUSCH-Persistent          INTEGER (-126..24)
                p0-UE-PUSCH-Persistent               INTEGER (-0..7)
                }       OPTIONAL,                                          --Need OP
                twoIntervalsConfig              ENUMERATED  {true}    OPTIONAL,  --Cond TDD
                ...
  }
}
N1- PUCCH-AN-PersistentList  : : =    SEQUENCE  (SIZE (1..4))  OF  INTEGER (0.. 2047)
-- ASN1STOP
```

FIG. 8

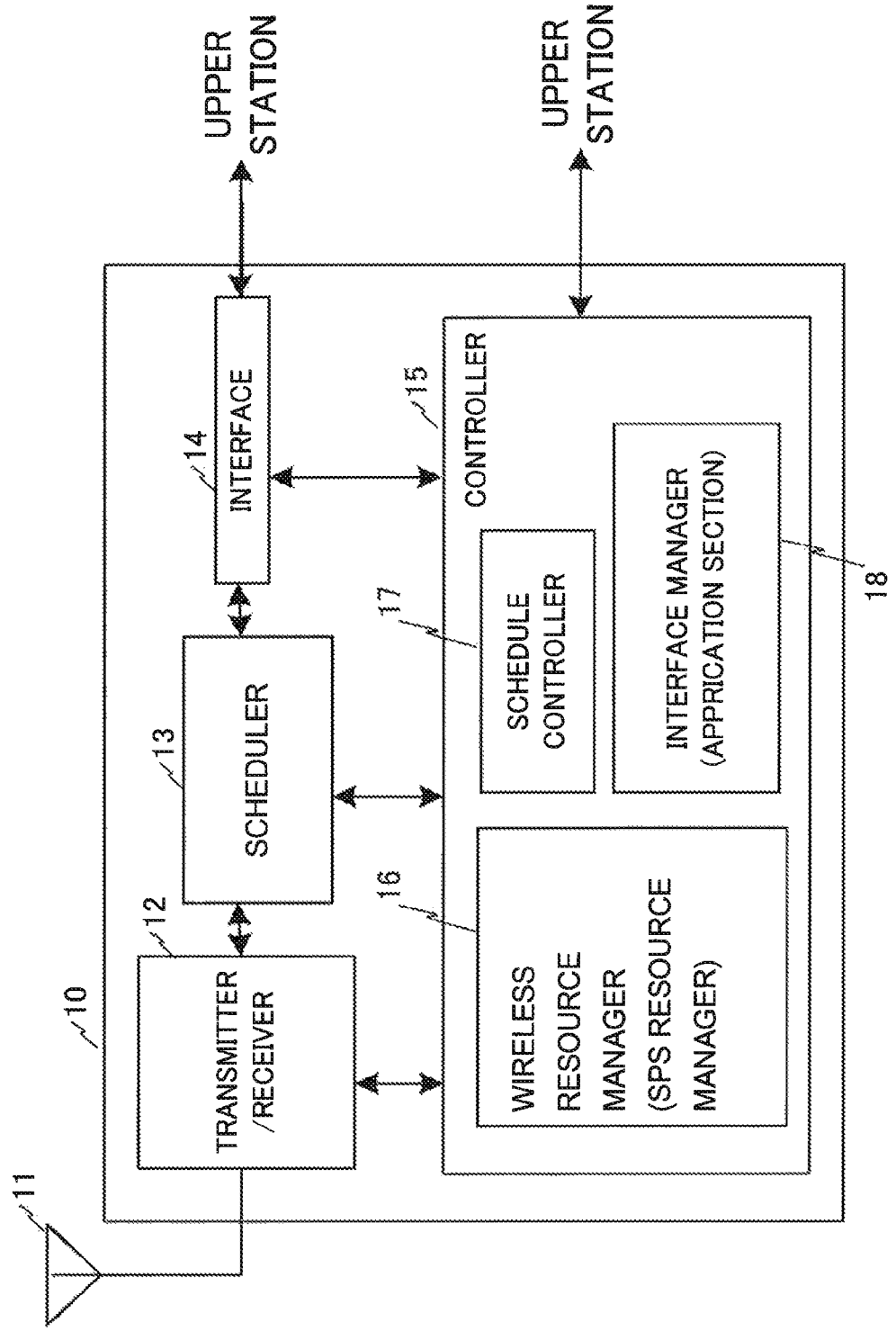

UPPER STATION
UPPER STATION
INTERFACE
14
15
CONTROLLER
SCHEDULE CONTROLLER
17
INTERFACE MANAGER (APPRICATION SECTION)
18
SCHEDULER
13
16
WIRELESS RESOURCE MANAGER (SPS RESOURCE MANAGER)
12
TRANSMITTER /RECEIVER
10
11

FIG. 9

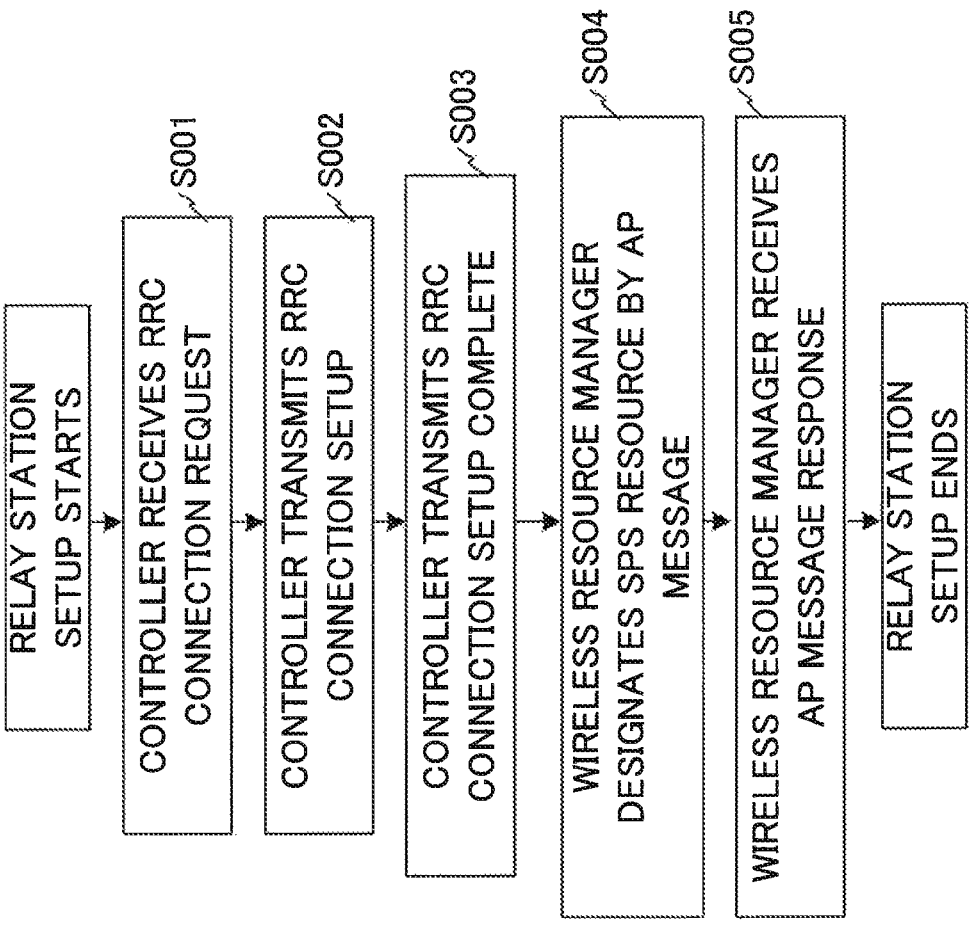

RELAY STATION SETUP STARTS
CONTROLLER RECEIVES RRC CONNECTION REQUEST
S001
CONTROLLER TRANSMITS RRC CONNECTION SETUP
S002
CONTROLLER TRANSMITS RRC CONNECTION SETUP COMPLETE
S003
WIRELESS RESOURCE MANAGER DESIGNATES SPS RESOURCE BY AP MESSAGE
S004
WIRELESS RESOURCE MANAGER RECEIVES AP MESSAGE RESPONSE
S005
RELAY STATION SETUP ENDS

FIG. 10

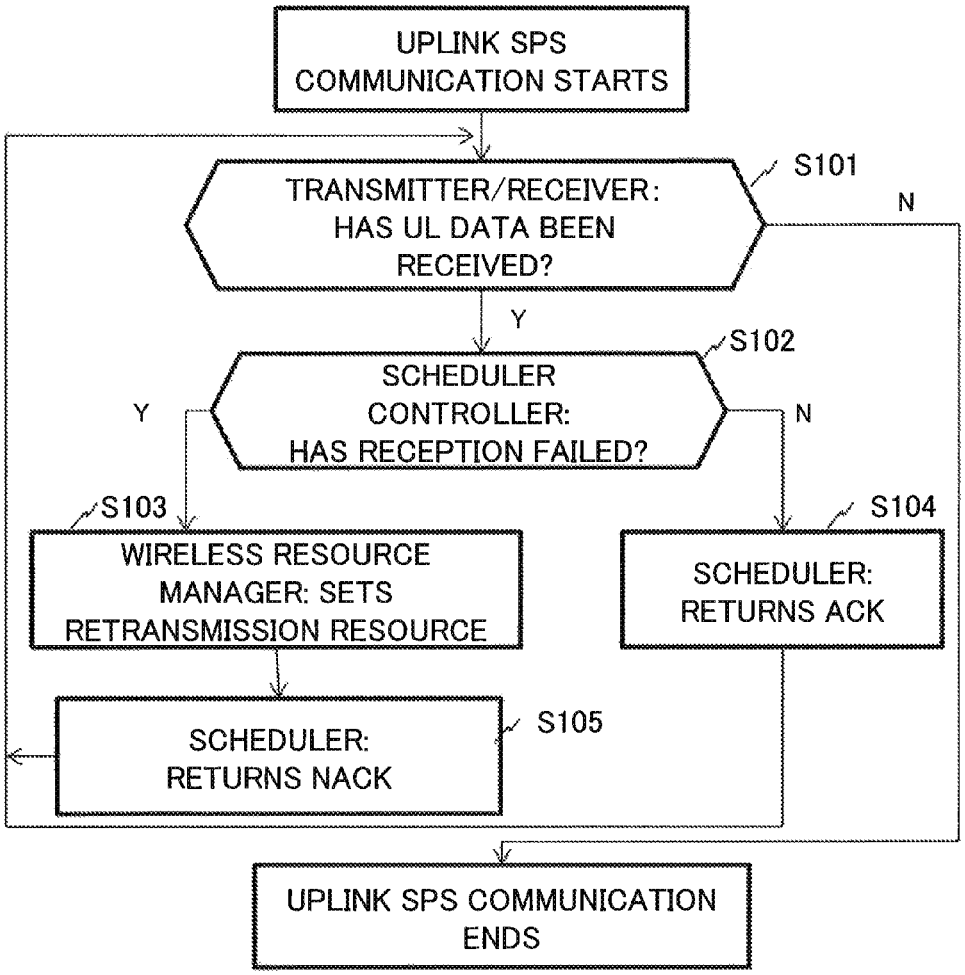

UPLINK SPS COMMUNICATION STARTS
TRANSMITTER/RECEIVER: HAS UL DATA BEEN RECEIVED?
S101
N
Y
SCHEDULER CONTROLLER: HAS RECEPTION FAILED?
S102
Y
N
S103
WIRELESS RESOURCE MANAGER: SETS RETRANSMISSION RESOURCE
S104
SCHEDULER: RETURNS ACK
SCHEDULER: RETURNS NACK
S105
UPLINK SPS COMMUNICATION ENDS

FIG. 11

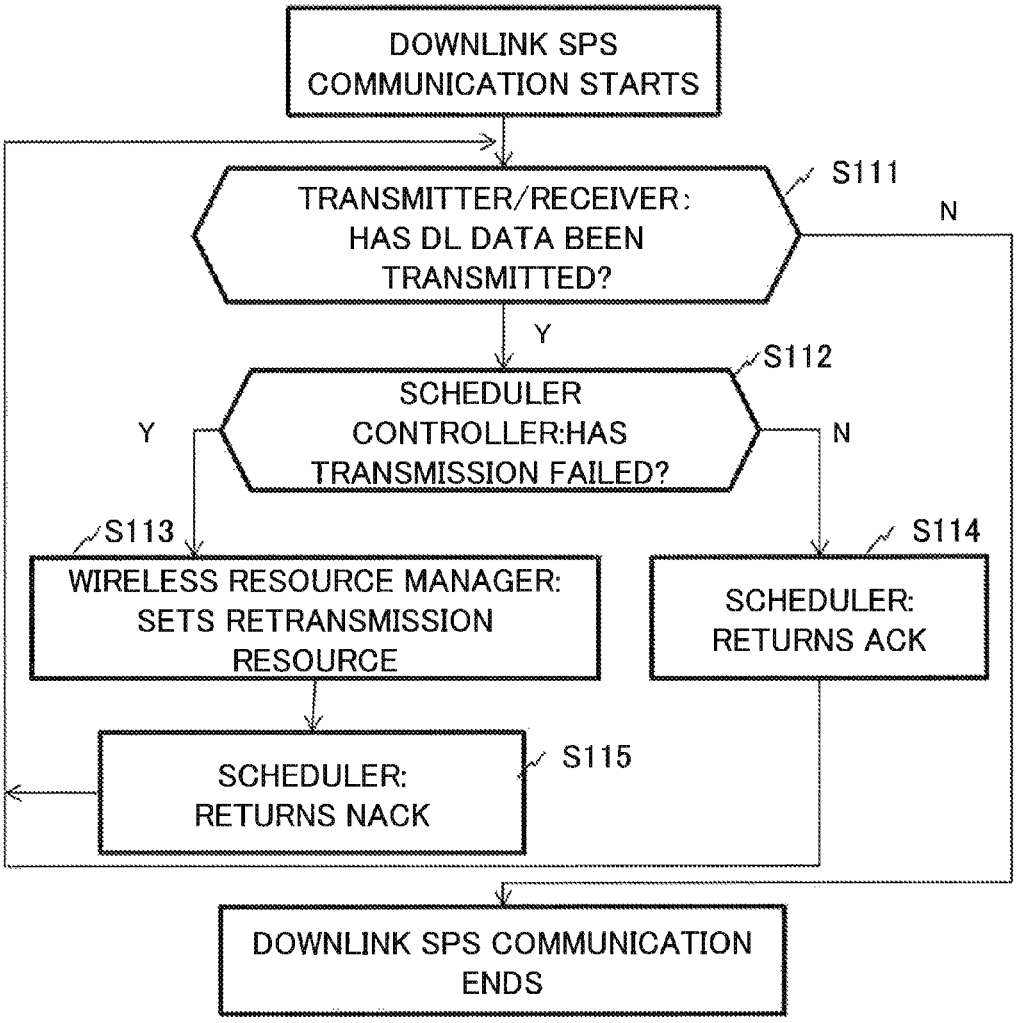

DOWNLINK SPS COMMUNICATION STARTS
S111
TRANSMITTER/RECEIVER: HAS DL DATA BEEN TRANSMITTED?
N
Y
S112
SCHEDULER CONTROLLER:HAS TRANSMISSION FAILED?
Y
N
S113
WIRELESS RESOURCE MANAGER: SETS RETRANSMISSION RESOURCE
S114
SCHEDULER: RETURNS ACK
S115
SCHEDULER: RETURNS NACK
DOWNLINK SPS COMMUNICATION ENDS

FIG. 12

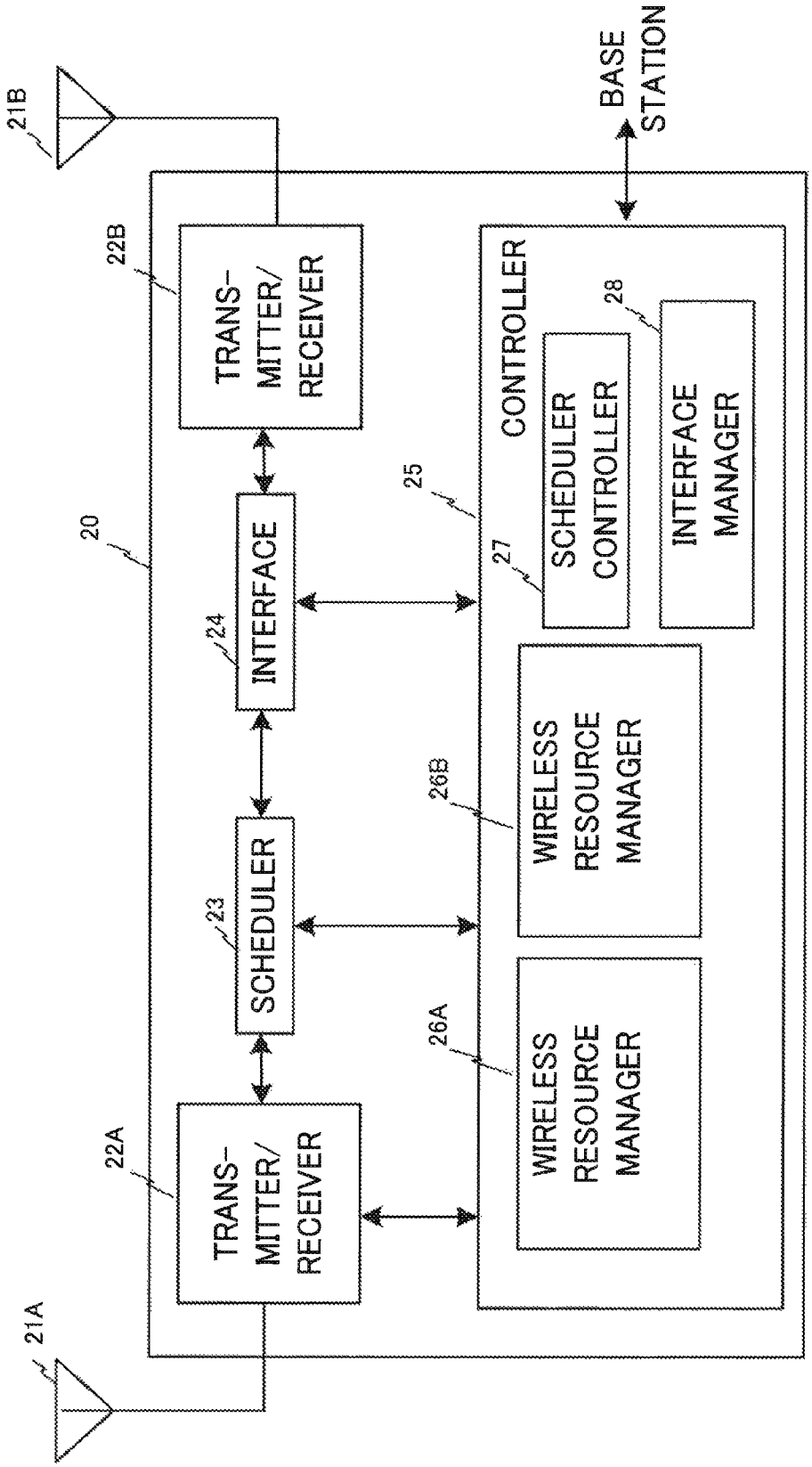

BASE STATION
21B
21A
20
22B
22A
TRANS-MITTER/ RECEIVER
TRANS-MITTER/ RECEIVER
24
INTERFACE
23
SCHEDULER
25
CONTROLLER
27
SCHEDULER CONTROLLER
28
INTERFACE MANAGER
26B
WIRELESS RESOURCE MANAGER
26A
WIRELESS RESOURCE MANAGER

FIG. 13

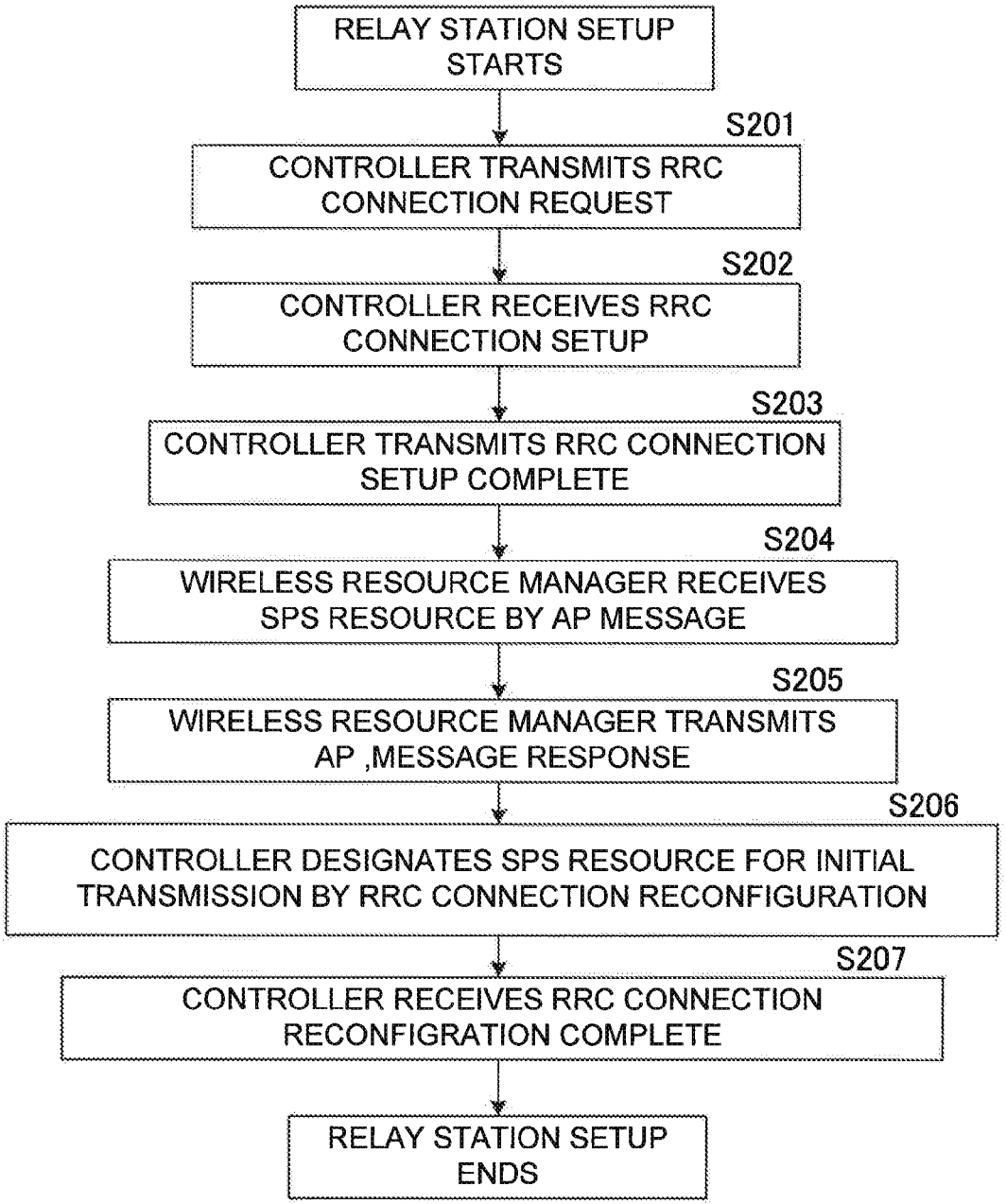

RELAY STATION SETUP STARTS
S201
CONTROLLER TRANSMITS RRC CONNECTION REQUEST
S202
CONTROLLER RECEIVES RRC CONNECTION SETUP
S203
CONTROLLER TRANSMITS RRC CONNECTION SETUP COMPLETE
S204
WIRELESS RESOURCE MANAGER RECEIVES SPS RESOURCE BY AP MESSAGE
S205
WIRELESS RESOURCE MANAGER TRANSMITS AP ,MESSAGE RESPONSE
S206
CONTROLLER DESIGNATES SPS RESOURCE FOR INITIAL TRANSMISSION BY RRC CONNECTION RECONFIGURATION
S207
CONTROLLER RECEIVES RRC CONNECTION RECONFIGRATION COMPLETE
RELAY STATION SETUP ENDS

FIG. 14

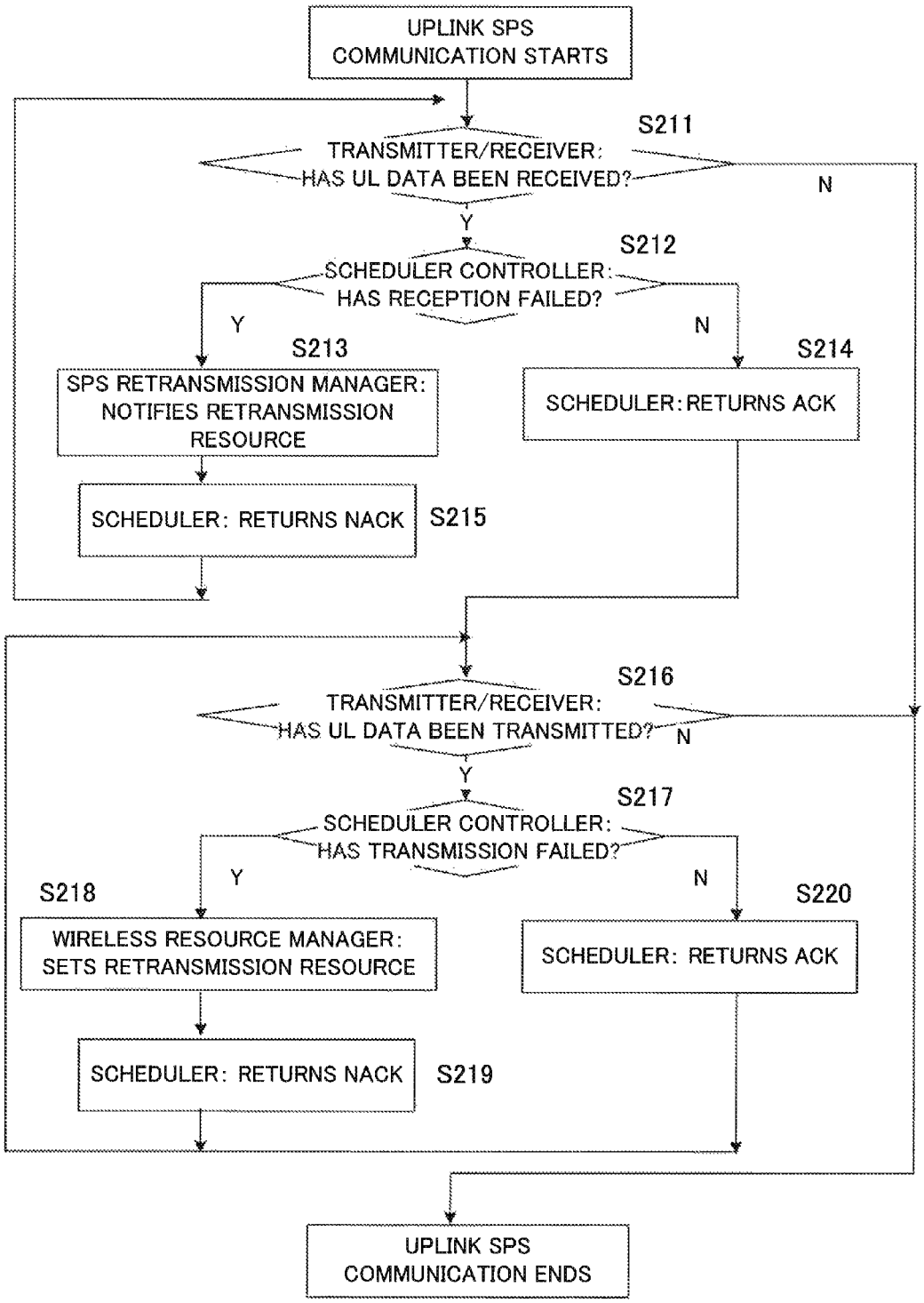

UPLINK SPS COMMUNICATION STARTS
S211
TRANSMITTER/RECEIVER: HAS UL DATA BEEN RECEIVED?
N
Y
S212
SCHEDULER CONTROLLER: HAS RECEPTION FAILED?
Y
N
S213
SPS RETRANSMISSION MANAGER: NOTIFIES RETRANSMISSION RESOURCE
S214
SCHEDULER: RETURNS ACK
SCHEDULER: RETURNS NACK
S215
S216
TRANSMITTER/RECEIVER: HAS UL DATA BEEN TRANSMITTED?
N
Y
S217
SCHEDULER CONTROLLER: HAS TRANSMISSION FAILED?
Y
N
S218
S220
WIRELESS RESOURCE MANAGER: SETS RETRANSMISSION RESOURCE
SCHEDULER: RETURNS ACK
SCHEDULER: RETURNS NACK
S219
UPLINK SPS COMMUNICATION ENDS

FIG. 15

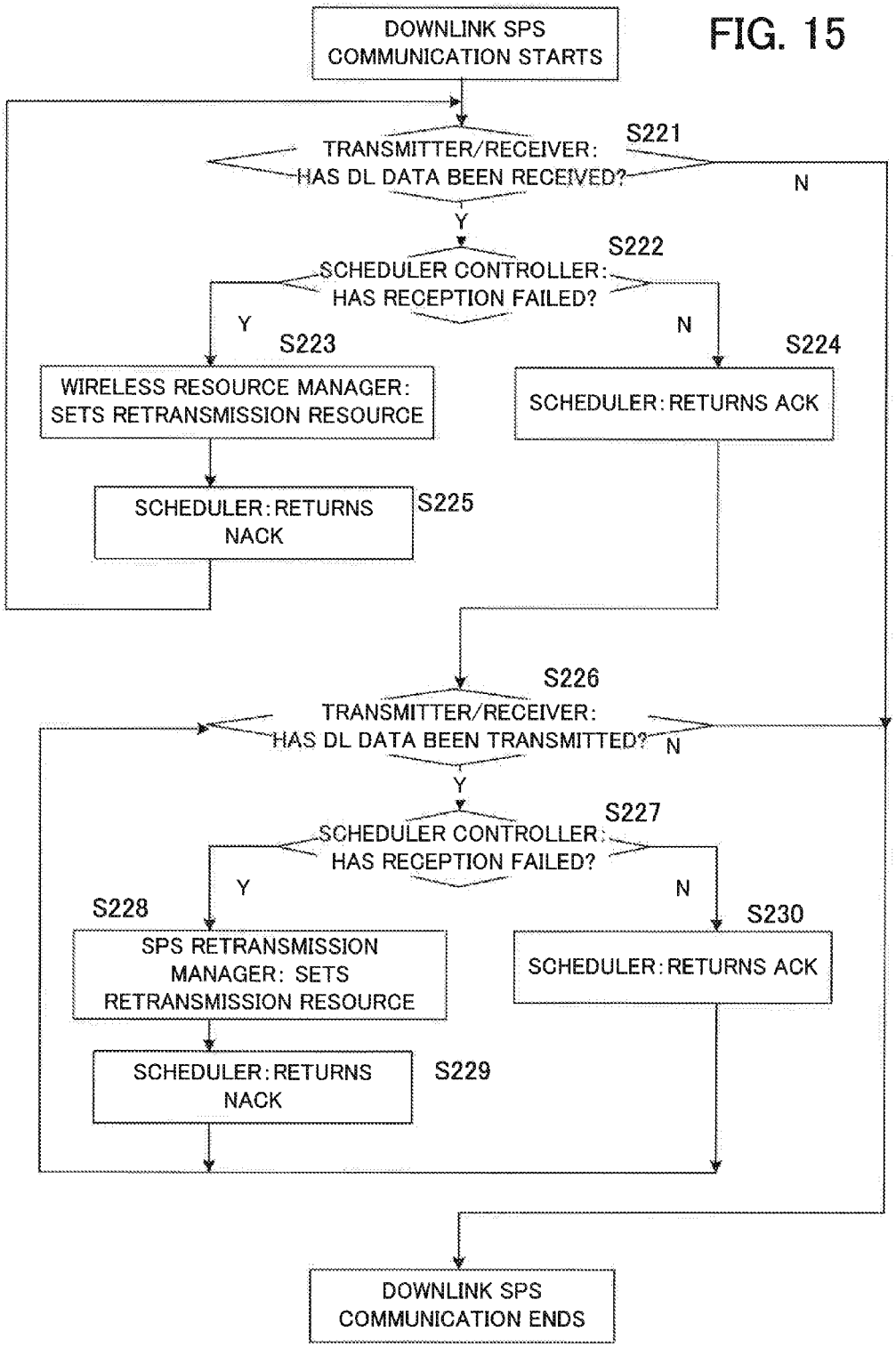

DOWNLINK SPS COMMUNICATION STARTS
TRANSMITTER/RECEIVER: HAS DL DATA BEEN RECEIVED?
S221
N
Y
SCHEDULER CONTROLLER: HAS RECEPTION FAILED?
S222
Y
N
S223
S224
WIRELESS RESOURCE MANAGER: SETS RETRANSMISSION RESOURCE
SCHEDULER: RETURNS ACK
SCHEDULER: RETURNS NACK
S225
S226
TRANSMITTER/RECEIVER: HAS DL DATA BEEN TRANSMITTED?
N
Y
SCHEDULER CONTROLLER: HAS RECEPTION FAILED?
S227
Y
N
S228
S230
SPS RETRANSMISSION MANAGER: SETS RETRANSMISSION RESOURCE
SCHEDULER: RETURNS ACK
SCHEDULER: RETURNS NACK
S229
DOWNLINK SPS COMMUNICATION ENDS

FIG. 16

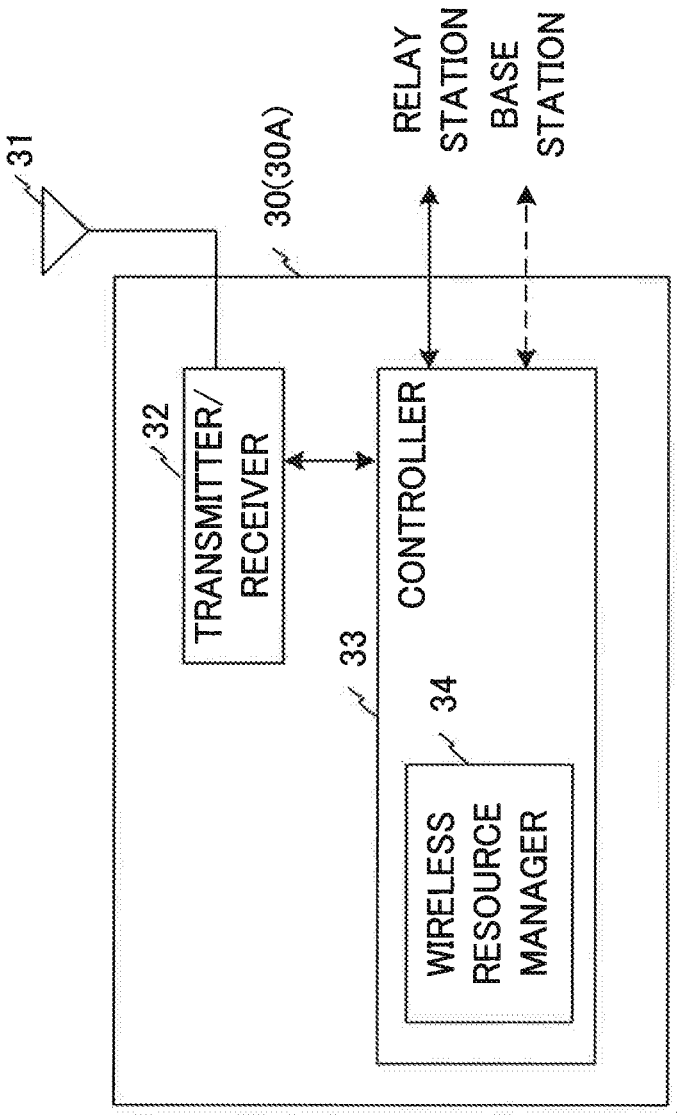

31
30(30A)
RELAY STATION
BASE STATION
32
TRANSMITTER/ RECEIVER
33
CONTROLLER
34
WIRELESS RESOURCE MANAGER

FIG. 17

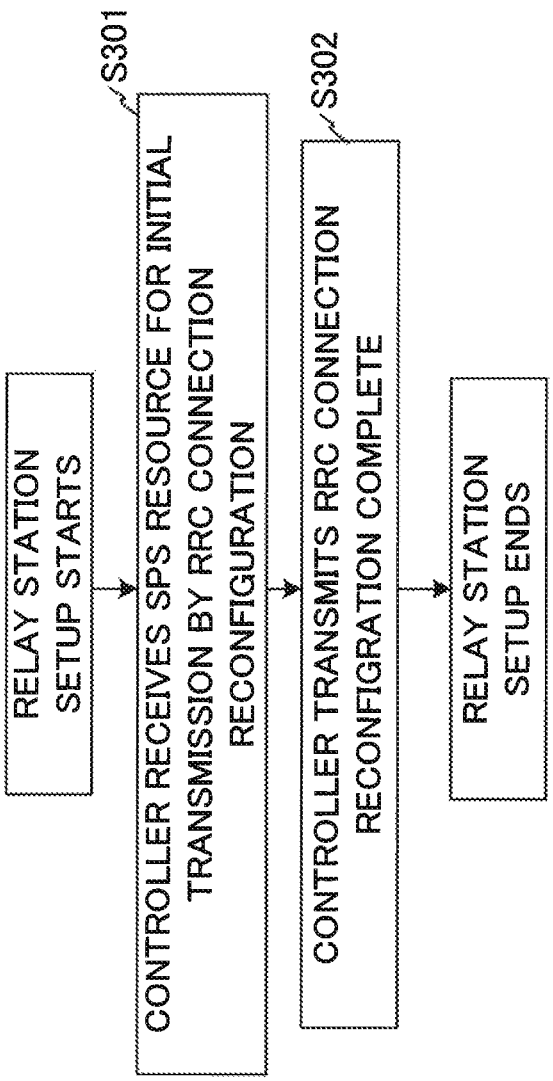

RELAY STATION SETUP STARTS
S301
CONTROLLER RECEIVES SPS RESOURCE FOR INITIAL TRANSMISSION BY RRC CONNECTION RECONFIGURATION
S302
CONTROLLER TRANSMITS RRC CONNECTION RECONFIGRATION COMPLETE
RELAY STATION SETUP ENDS

FIG. 18

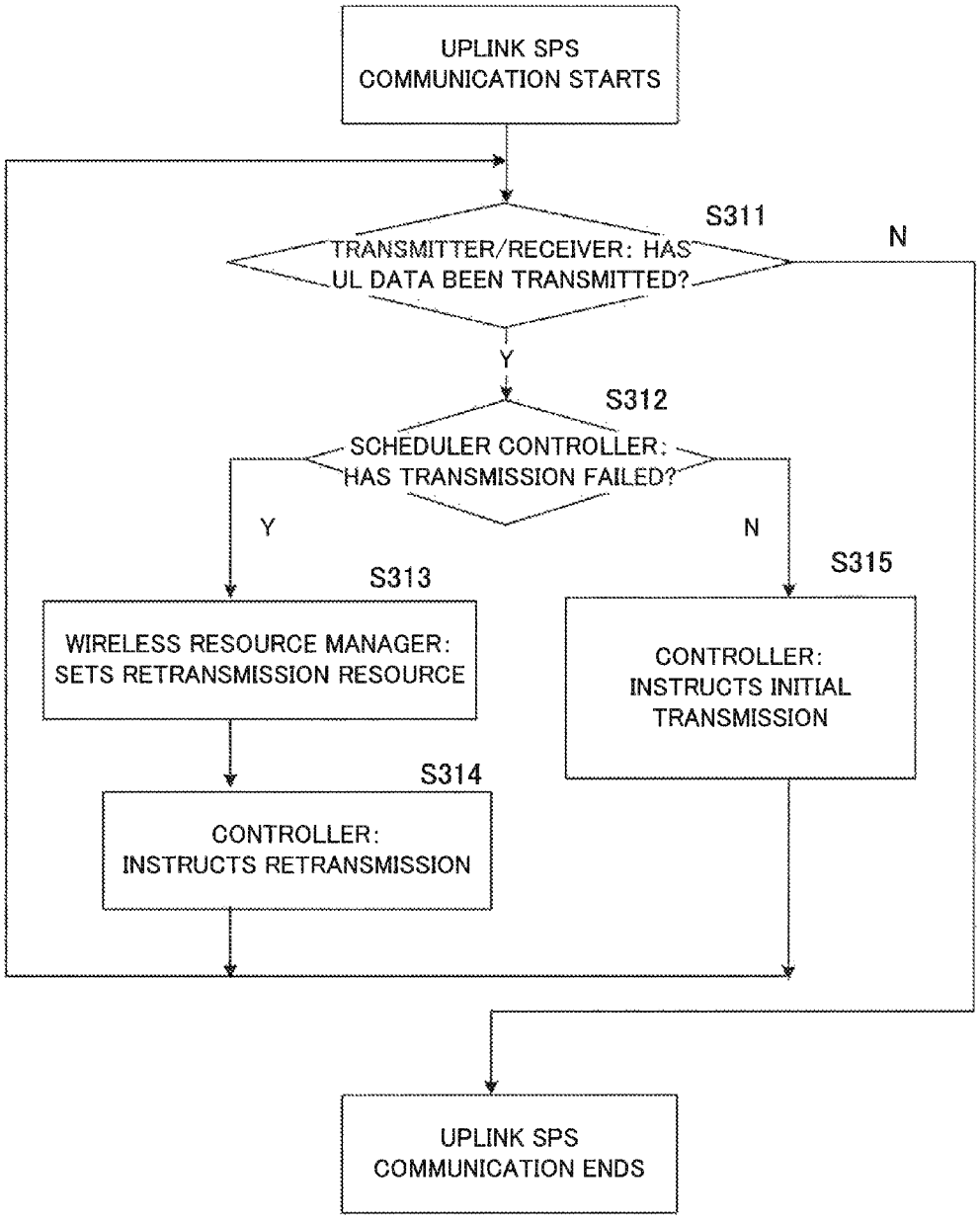

UPLINK SPS COMMUNICATION STARTS
S311
TRANSMITTER/RECEIVER: HAS UL DATA BEEN TRANSMITTED?
N
Y
S312
SCHEDULER CONTROLLER: HAS TRANSMISSION FAILED?
Y
N
S313
WIRELESS RESOURCE MANAGER: SETS RETRANSMISSION RESOURCE
S314
CONTROLLER: INSTRUCTS RETRANSMISSION
S315
CONTROLLER: INSTRUCTS INITIAL TRANSMISSION
UPLINK SPS COMMUNICATION ENDS

FIG. 19

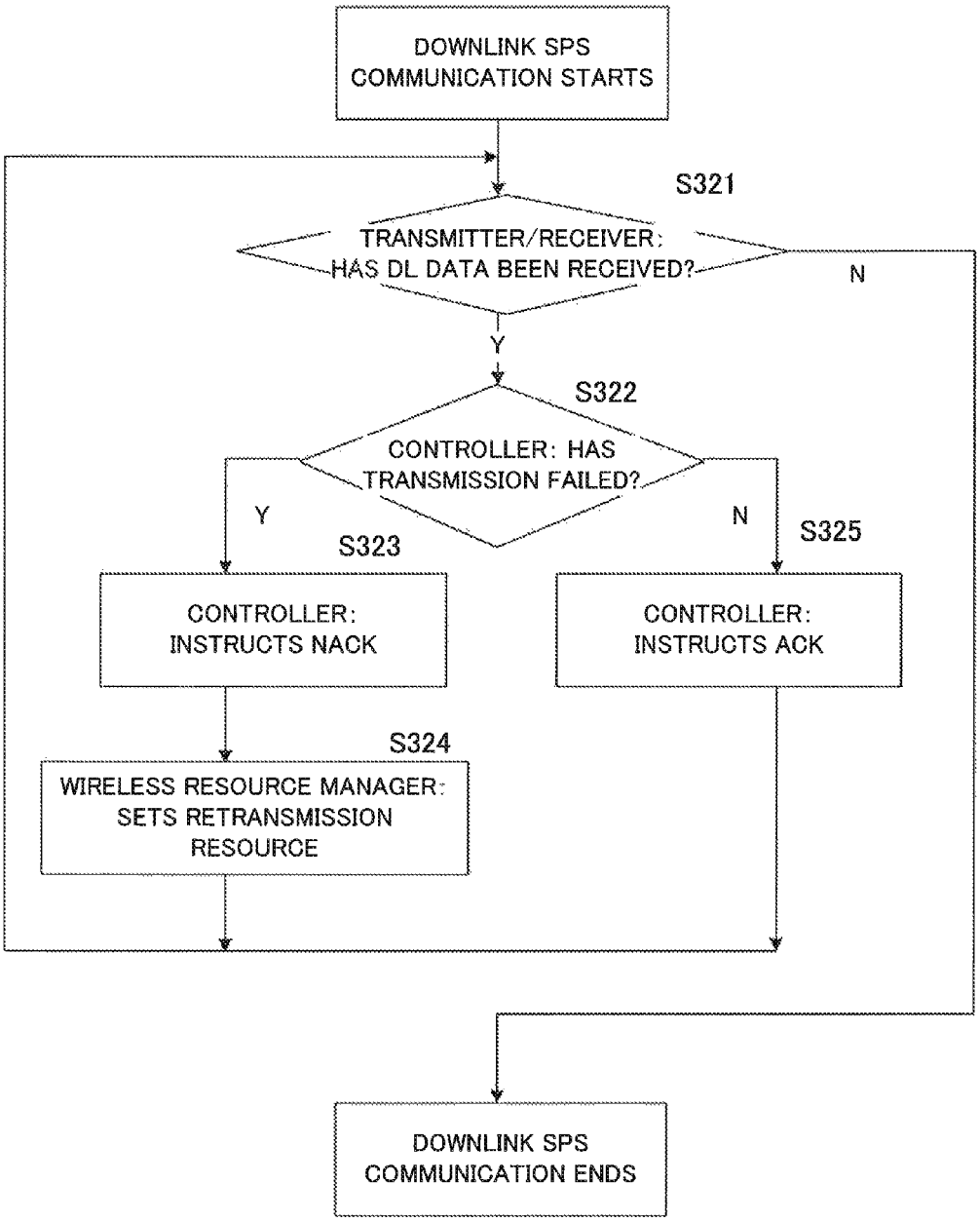

DOWNLINK SPS COMMUNICATION STARTS
S321
TRANSMITTER/RECEIVER: HAS DL DATA BEEN RECEIVED?
N
Y
S322
CONTROLLER: HAS TRANSMISSION FAILED?
Y
N
S323
S325
CONTROLLER: INSTRUCTS NACK
CONTROLLER: INSTRUCTS ACK
S324
WIRELESS RESOURCE MANAGER: SETS RETRANSMISSION RESOURCE
DOWNLINK SPS COMMUNICATION ENDS

FIG. 20 RELATED ART

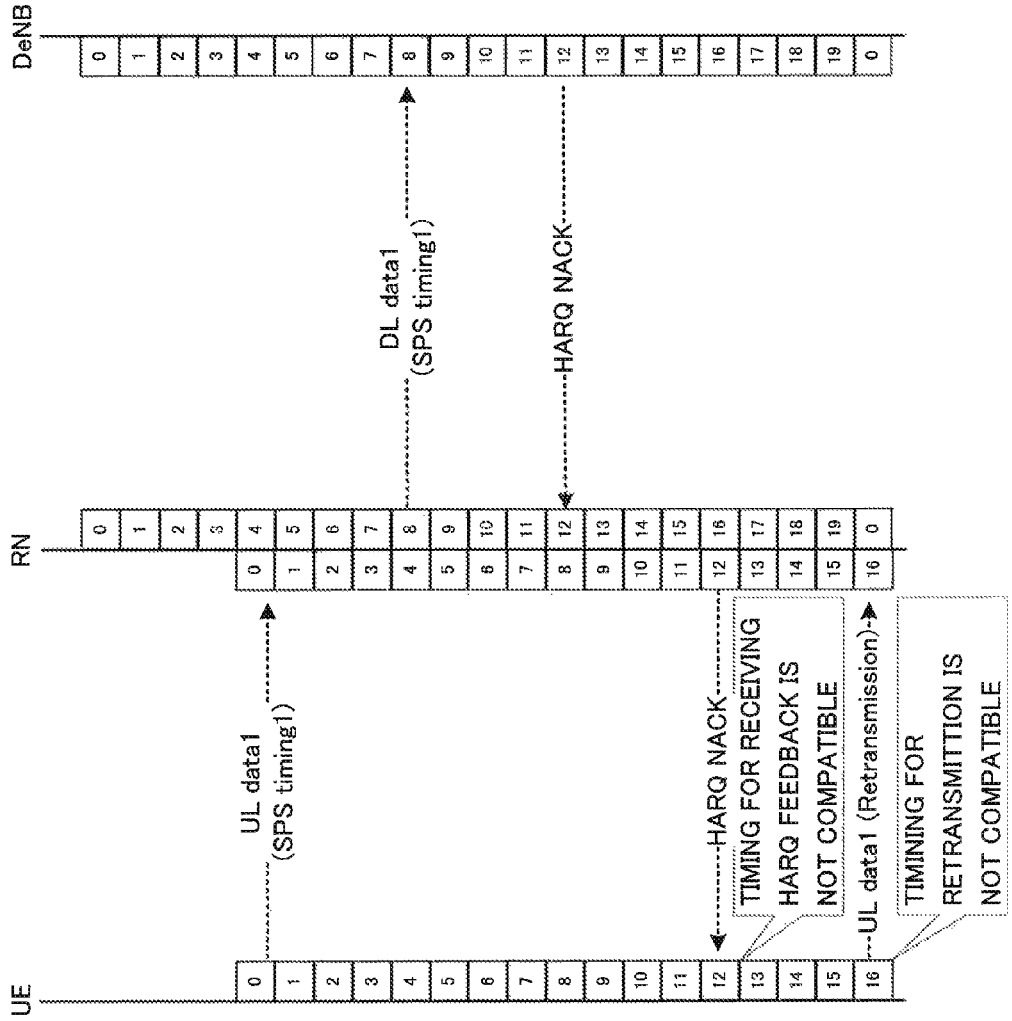
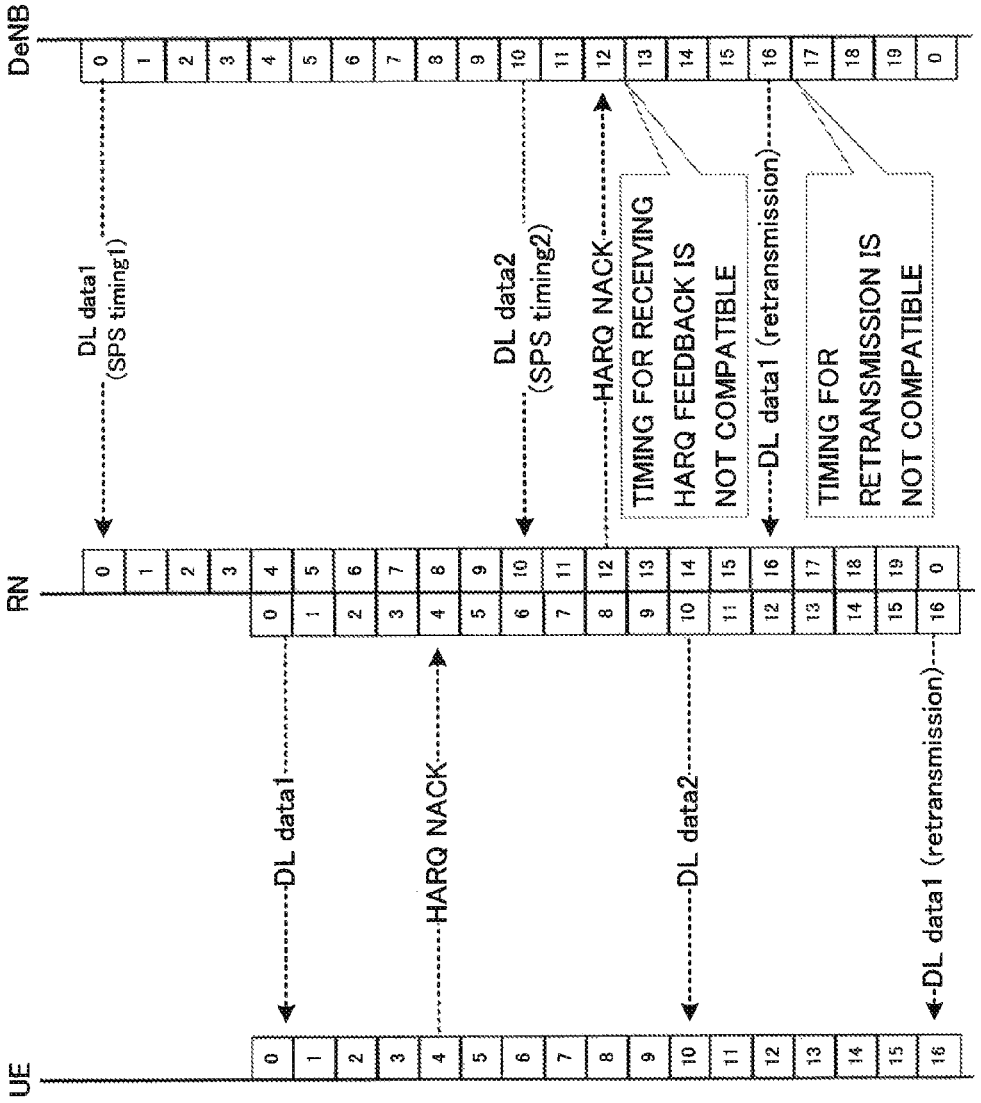


FIG. 21 RELATED ART



MOBILE COMMUNICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the International Patent Application No. PCT/JP2010/054360, filed on Mar. 15, 2010, the contents of which are herein wholly incorporated by reference.

FIELD

The disclosure relates to a mobile communication system.

BACKGROUND

Cellular-type mobile communication has evolved from UMTS (Universal Mobile Telecommunication System) to LTE (Long Term Evolution). In LTE, an OFDM (Orthogonal Frequency Division Multiplexing) based system is provided as a wireless access technique. According to LTE, high-speed wireless packet communication with a downlink peak transmission rate of 100 Mbps or more and an uplink peak transmission rate of 50 Mbps or more becomes possible.

Currently, the 3GPP (3rd Generation Partnership Project), an international standardization body, has started examination of LTE-A (LTE-Advanced), an LTE-based mobile communication system, for realization of higher-speed communication. LTE-A aims at a downlink peak transmission rate of 1 Gbps and an uplink peak transmission rate of 500 Mbps, and various new techniques, such as wireless access methods and network architectures, are examined (for example, Non-Patent document 1). On the other hand, LTE-A is required to be compatible with LTE because it is an LTE-based system.

As one of methods for performing high-speed data communication, a method of introducing a relay station to support communication between a base station and a mobile station is examined. The relay station intervenes between a conventional base station and mobile station, and it is installed to support high-speed data communication. As the relay station, for example, a relay station which only amplifies a wireless signal (a data signal and noise) (a repeater system), a relay station capable of amplifying only a data signal in a wireless signal (a decode-and-forward system), a relay station implemented with functions of Layer **2** (L**2**: (such as a MAC (Media Access Control) layer or the like) (an L**2** relay station), and a relay station implemented with functions of Layer **3** (L**3** (an RRC (Radio Resource Control) layer)) and behaving as a station having functions equivalent to those of a base station (L**3** system) are examined.

A method of developing relay stations in a cell is also examined. For example, a method of developing relay stations at cell ends for the purpose of increasing the throughput at the cell ends or a method of developing relay stations within a range where radio waves do not reach (blind zones) are examined.

[Non-Patent document 1] 3GPP TR 36.913, "Requirements for further advancements for Evolved UniversalLTErrestrial Radio Access (E-UTRA) (LTE-Advanced)", V8.0.1, Release 8, May 2009.

In data communication via a relay station, the relay station is involved in conventional data communication between a base station and a mobile station. As matters to be examined for scheduling of data transmission in consideration of a relay station, a wireless resource management method and an HARQ (Hybrid Automatic Repeat Request) control method are given. Here, HARQ is a data retransmission system in which a retransmission pattern is determined in consideration of the point that, on the receiving side, such data that decoding has failed may be combined with retransmitted data without being discarded.

From a viewpoint of a scheduling execution place, scheduling is roughly classified into two systems: centralized scheduling and distributed scheduling. In the centralized scheduling, a base station which controls a relay station executes scheduling of data transmission related to relay stations under the base station and mobile stations under the relay stations. On the other hand, in the distributed scheduling, a base station which controls relay stations executes only scheduling of data transmission related to mobile stations connected to the base station itself, and the relay stations execute only scheduling of data transmission related to mobile stations related to the relay stations themselves.

As for the wireless resource management method, in LTE, management of wireless resources is controlled by the RRC layer of a base station. In comparison, in LTE-A, a relay station is also involved in communication. Therefore, a wireless resource management place and method are examined. In LTE-A, one or more L**3**-system relay stations having functions equivalent to those of a base station may be installed in the cell of a base station. Here, the base station controlling the relay stations are called a donor base station (Donor eNB). The donor base station and the relay stations may communicate between the RRC layers. Therefore, by performing wireless resource management in cooperation between the RRC layers, it is possible to perform efficient wireless resource management.

As the method for wireless resource management by scheduling, there are dynamic scheduling and semi-persistent scheduling (SPS). The dynamic scheduling is used for non-real-time type communication such as communication for web browsing. In the dynamic scheduling, wireless resources used for a PDCCH (Physical Downlink Control Channel) are specified in both of uplink communication and downlink communication. In comparison, the semi-persistent scheduling (SPS) is used for real-time type communication represented by VoIP (Voice over IP). In the SPS, wireless resources are fixedly allocated for a certain predetermined period, before communication is actually executed. For example, in VoIP communication, initial transmission of data occurs every 20 ms. Therefore, wireless resources to be used are notified every 20 ms. However, when retransmission of data is executed, the dynamic scheduling is used.

As the HARQ control method, there is a control system described below. In LTE, an asynchronous HARQ system is adopted for downlink communication, and a synchronous HARQ system is adopted for uplink communication.

In LTE-A, it is required to support the above asynchronous HARQ system and synchronous HARQ system for at least LTE mobile stations in order to secure compatibility with LTE.

The asynchronous HARQ system is a method of receiving a confirmation response (ACK or NACK) to downlink transmission after 4 ms and, when the confirmation response is NACK, executing downlink retransmission at an arbitrary timing. In the asynchronous HARQ system, a base station is required to notify a mobile station of data transmission, necessarily using a PDCCH. On the other hand, the asynchronous HARQ system is a method of receiving a confirmation response to uplink transmission after 4 ms and, when the confirmation response is NACK, executing uplink retransmission 4 ms after the reception. In the asynchronous HARQ system, the base station is not required to notify a mobile station of data transmission by a PDCCH. In other words, a

mobile station may retransmit data without receiving notification by the PDCCH. As described above, in the asynchronous HARQ system, it is possible to retransmit data without a PDCCH and, therefore, reduce signaling overhead.

When a relay station is involved in data communication between a base station and a mobile station in LTE-A, data processing time at the relay station occurs. Therefore, development of a method for maintaining the timing provided for the synchronous HARQ system or the asynchronous HARQ system as described above has been desired. That is, there may be a case that compatibility with the synchronous HARQ system or asynchronous HARQ system provided in LTE cannot be maintained due to intervention of a relay station between a mobile station and the base station.

FIG. **20** is a diagram illustrating an example of HARQ timing in uplink communication. FIG. **20** illustrates an example of a case that data is transmitted from a mobile station (UE: User Equipment) to a donor base station (DeNB) via a relay station (RN: Relay Node).

In the example illustrated in FIG. **20**, wireless resources (a transmission timing) used for data transmission by the mobile station (UE) and the relay station (RN) are determined in advance by the SPS. In the example illustrated in FIG. **20**, the UE transmits data (data **1**) to the relay station at a timing in accordance with the SPS, that is, at a sub-frame number "0" (1 sub-frame: 1 ms) between the mobile station and the relay station.

The relay station relays the data **1** from the mobile station to the donor base station at a timing in accordance with the SPS, that is, at a sub-frame number "8" between the relay station and the donor base station. The donor base station returns a confirmation response (ACK or NACK) to the relay station at a sub-frame number "12" 4 ms after the sub-frame number "8" in accordance with the synchronous HARQ system. At this time, when failing in decoding (normal reception) of the data **1**, the donor base station returns a NACK (HARQ NACK) message indicating the failure, to the relay station at the sub-frame number "12" in accordance with the synchronous HARQ system.

The relay station transfers the HARQ NACK message to the mobile station at a sub-frame number "12" between the mobile station and the relay station corresponding to 4 ms after the sub-frame number "12" in accordance with the synchronous HARQ system. Therefore, the mobile station receives the HARQ NACK message to the data **1** at the sub-frame number "12." Then, the mobile station retransmits the data **1** at a sub-frame number "16" after 4 ms in accordance with the synchronous HARQ system.

According to the synchronous HARQ system in LTE, however, the HARQ NACK message (HARQ feedback) from the donor base station should be received at a sub-frame number "4" 4 ms after the sub-frame number "0." The retransmission of the data **1** from the mobile station should be performed at a sub-frame number "8" after elapse of 4 ms after the sub-frame number "4." As described above, there is a problem that, when the relay station intervenes, an operation which is not compatible with the synchronous HARQ system of LTE occurs.

FIG. **21** is a diagram illustrating an example of HARQ timing in downlink communication. FIG. **21** illustrates an example of a case that data is transmitted from a donor base station (DeNB) to a mobile station (UE: User Equipment) via a relay station (RN: Relay Node). In the example illustrated in FIG. **21**, the donor base station transmits data to a mobile station every ten sub-frames in accordance with the SPS. For example, data (data **1**) from the donor base station is transmitted to the relay station at a sub-frame number "0" between the relay station and the base station. The relay station transfers the data **1** to the mobile station at a sub-frame number "4" (a sub-frame number "0" between the mobile station and the relay station) after elapse of 4 ms.

The mobile station returns a confirmation response (ACK or NACK) to the relay station at a sub-frame number "4" 4 ms after the sub-frame number "0" in accordance with the asynchronous HARQ system. In this case, when decoding (normal reception) of the data **1** fails, a NACK (HARQ NACK) message is returned.

The relay station returns a NACK message to the donor station at a sub-frame number "12" (between the relay station and the donor station) after elapse of 4 ms in accordance with the asynchronous HARQ system. The donor base station retransmits the data **1** to the relay station at an arbitrary timing, for example, at a sub-frame number "16" as illustrated in FIG. **21** in accordance with the asynchronous HARQ system. The relay station relays the retransmission of the data **1** to the mobile station after elapse of 4 ms.

As described above, when the relay station intervenes, the donor station cannot receive a confirmation response at a timing in accordance with the asynchronous HARQ system (the original reception timing is the sub-frame number "4") even in downlink communication.

SUMMARY

An embodiment of the present invention is a mobile communication system, comprising: a base station; and a relay station to relay data transmitted/received between the base station and a mobile station.

The base station includes: a first scheduler configured to perform scheduling of initial transmission of the data transmitted/received between the base station and the mobile station via the relay station; and a first manager configured to manage predetermined wireless resources which are periodically used, as wireless resources used for the initial transmission of the data.

The relay station includes: a second scheduler configured to perform scheduling of transmission of a message for confirming necessity of retransmission of the data and retransmission of the data; and a second manager configured to manage wireless resources used for the transmission of the message and the retransmission of the data.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a configuration example of a mobile communication system according to an embodiment of the present invention;

FIG. **2** is an explanatory diagram of an interface between a base station and a relay station (Un interface) and an interface between the relay station and a mobile station (Uu interface);

FIG. **3** is a diagram illustrating an example of HARQ timing in uplink communication in the embodiment;

FIG. **4** is a diagram illustrating an example of HARQ timing in downlink communication in the embodiment;

FIG. **5** is a diagram illustrating an example of a procedure for setting of wireless resources for the Uu interface by a base station **10** in the embodiment;

FIG. **6** illustrates a format example of a Radio Resource Config Dedicated message;

FIG. **7** illustrates a format example of sps-Configuration;

FIG. **8** illustrates a configuration example of a base station apparatus;

FIG. **9** is a flowchart illustrating an operation example of the base station apparatus at the time of setup of the relay station described in FIG. **5**;

FIG. **10** is a flowchart illustrating an operation example (an uplink SPS communication process) of the base station apparatus at the time of uplink SPS communication described in FIG. **3**;

FIG. **11** is a flowchart illustrating an operation example (a downlink SPS communication process) of the base station apparatus at the time of downlink SPS communication described in FIG. **4**;

FIG. **12** is a diagram illustrating a configuration example of a relay station apparatus;

FIG. **13** is a flowchart illustrating an operation example (a setup process) at the time of setup of the relay station apparatus;

FIG. **14** is a flowchart illustrating an operation example (an uplink communication process) of the relay station apparatus at the time of uplink SPS communication;

FIG. **15** is a flowchart illustrating an operation example (a downlink communication process) of the relay station apparatus at the time of downlink SPS communication;

FIG. **16** is a diagram illustrating a configuration example of a mobile station apparatus;

FIG. **17** is a flowchart illustrating an operation example (a setup process) of the mobile station apparatus at the time of setup of the relay station;

FIG. **18** is a flowchart illustrating an operation example (an uplink SPS communication process) of the mobile station apparatus at the time of uplink SPS communication;

FIG. **19** is a flowchart illustrating an operation example (a downlink SPS communication process) of the mobile station apparatus at the time of downlink SPS communication;

FIG. **20** illustrates an example of uplink SPS communication when the relay station intervenes; and

FIG. **21** illustrates an example of downlink SPS communication when the relay station intervenes.

DESCRIPTION OF THE EMBODIMENT

An embodiment of the present invention will be described below with reference to drawings. The configuration in the embodiment is illustrated as an example, and the present invention is not limited to the configuration of the embodiment.

<Mobile Communication System>

FIG. **1** illustrates a configuration example of a mobile communication system according to the embodiment of the present invention. In FIG. **1**, the mobile communication system is provided with a donor station (DeNB) **10** (hereinafter referred to simply as "base station **10**") and one or more relay stations (RNs) **20** controlled by the base station **10**. Though three relay stations **20**A, **20**B and **20**C (hereinafter referred to as "relay station (s) **20**" when the relay stations **20**A to **20**C are not distinguished from one another) are illustrated in the example illustrated in FIG. **1**, any number of relay stations **20** may be installed.

The relay stations **20** are installed at appropriate positions in a communication range (cell) C**1** of the base station **10**. The relay stations **20**A, **20**B and **20**C have communication areas (cells) C**2**, C**3** and C**4**, respectively, and each of them may communicate with a mobile station (UE) **30** existing in its cell to relay communication between the mobile station **30** and the base station **10**. In the example illustrated in FIG. **1**, a mobile station **30**A existing in the cell C**2** of the relay stations **20**A, a mobile station **30**B existing in the cell C**3** of the relay stations **20**B, and a mobile station **30**C existing in the cell C**4** of the relay stations **20**C are illustrated. Hereinafter, the mobile stations **30**A to **30**C are referred to as "mobile station(s) **30**" when they are not distinguished from one another. The mobile stations **30** support LTE.

The relay stations **20** are relay stations implemented with L**3** (RRC (Radio Resource Control) protocol) functions (L**3** relay stations). The cells (C**2** to C**4**) of such relay stations **20** appear to be cells independent from the cell C**1** of the base station **10** when seen from the mobile stations **30**. Therefore, when seen from the mobile station **30** supporting LTE, the relay station **20** appears to be one base station.

That is, in the embodiment, the base station **10** and the relay stations **20** are connected via a network-side Un interface, and the relay stations **20** and the mobile station **30** are connected via a user-side Uu interface, as illustrated in FIG. **2**.

In this embodiment, scheduling of initial transmission of data (a transmission/reception timing of initially transmitted data) and wireless resources for the Un interface (between the base station and the relay station) involved in the initial transmission are managed by the base station **10**. The relay station **20** allocates wireless resources for the Uu interface (between the relation station and the mobile station) to the mobile station **30** in accordance with the initial transmission scheduling managed by the base station **10**. Furthermore, the relay station **20** manages scheduling of retransmission of data (transmission/reception timings of a confirmation response message and the retransmitted data) and wireless resources for the data retransmission.

<Uplink Communication>

In distribute scheduling in which the base station **10** is not involved in scheduling of data transmission/reception, the efficiency deteriorates when SPS (Semi-persistent Scheduling) is performed. In the SPS, allocated wireless resources are continuously used for a certain medium- or long-term predetermined period. In this case, there is a possibility that, depending on the communication position of the mobile station **30**, interference occurs between the base station **10** and the relay station **20**, and the interference continues for a certain medium-term period or long-term period.

For example, it may occur that, as a result of scheduling of wireless resources to the mobile stations **30** is performed independently by the base station **10** and the relay stations **20**, the same wireless resources (frequency and a time axis) are allocated to each of a mobile station **30** connected to the relay stations **20** and a mobile station **30** connected to the base station **10**, and each of the mobile stations **30** executes uplink transmission. In this case, radio waves emitted from the mobile stations **30** become mutual interference waves. When the wireless resources used by each mobile station **30** are allocated by the SPS, each mobile station continues to use the wireless resources for a medium- or long-term period, and medium- or long-term interference continues. Consequently, there is a possibility that the communication efficiency of each mobile station **30** deteriorates.

Therefore, in this embodiment, when the SPS is executed, wireless resources used for initial transmission of data in accordance with the SPS are managed by the base station **10**, and wireless resources used for retransmission of the data in accordance with the SPS are managed by the relay stations **20**.

FIG. **3** is a diagram illustrating an example of HARQ timing in uplink communication in this embodiment. FIG. **3**

illustrates an example of a case that data is transmitted from the mobile station (UE) **30** to the base station (DeNB) **10** via the relay station (RN) **20**.

In the example illustrated in FIG. **3**, wireless resources managed by the base station **10**, which are used for initial transmission of data to be transmitted from the mobile station **30** to the base station **10** via the relay station **20**, are allocated to the relay station **20** and the mobile station **30** in accordance with the SPS performed by the base station **10**. On the other hand, scheduling of retransmission of the data is performed by the relay station **20**, and wireless resources used in accordance with a result of the scheduling by the relay station **20** are managed by the relay station **20** and allocated to the mobile station **30** and the base station **10**.

Therefore, initially transmitted data which is transmitted from the mobile station **30** to the base station **10** is transmitted and received with the use of a result of SPS scheduling by the base station **10** and wireless resources allocated in accordance with the scheduling result.

In the example illustrated in FIG. **3**, the mobile station **30** transmits data (data **1**) to the relay station **20** at a timing in accordance with the SPS, that is, at a sub-frame number (a transmission timing) "0" (1 sub-frame: 1 ms) in the Uu interface between the mobile station and the relay station.

The relay station **20** returns a confirmation response message (ACK or NACK) at a sub-frame number "4" so that the mobile station **30** may receive the confirmation response message after elapse of 4 ms in accordance with the synchronous HARQ system applied to uplink communication in LTE. In this case, when failing in decoding (normal reception) of the data **1**, the relay station **20** returns an HARQ NACK message to the mobile station **30**.

The mobile station **30** receiving the HARQ NACK message at the sub-frame number "4" retransmits the data **1** to the relay station **20** at a sub-frame number "8" after elapse of 4 ms after the sub-frame number "4" in accordance with scheduling and wireless resource allocation performed by the relay stations **20** in accordance with the synchronous HARQ system.

When succeeding in decoding (normal reception) of the data **1**, the relay station **20** returns a confirmation response, a HARQ ACK message indicating the success to the mobile station **30** at a sub-frame number "12" after elapse of 4 ms in accordance with the synchronous HARQ system. On the other hand, the relay station **20** transmits the retransmitted data **1** to the base station **10** at a sub-frame number (a transmission timing) "16" of the Un interface corresponding to the sub-frame number "12" of the Uu interface. The base station **10** returns a confirmation response message (in FIG. **3**, HARQ ACK) to the relay station **20** at a sub-frame number "0" after 4 ms in accordance with the synchronous HARQ system.

As described above, according to the embodiment, since scheduling and wireless resources for initial transmission of data are managed by the base station **10**, the base station **10** may determine a transmission timing and wireless resource allocation for each of the mobile stations **30** in a manner that the multiple different mobile stations **30** do not use the same wireless resources (frequency and a time axis) at the same time. By such allocation of wireless resources for initial transmission being performed by the base station **10** being performed for each mobile station **30**, it is possible to avoid the mobile stations **30** using the same wireless resources at the same time. Thus, it is possible to prevent occurrence of interference for a medium- or long-term period because of the multiple mobile stations **30** using the same wireless resources for a medium- or long-term period by setting of the SPS as described above, and avoid deterioration of communication efficiency.

Furthermore, according to this embodiment, scheduling and wireless resources for retransmission of data are managed by the relay stations **20**. Thereby, it is possible to transmit a confirmation response message transmitted for retransmission of data and the data to be retransmitted at a desired timing. Thereby, even if the relay stations **20** intervenes between the base station **10** and the mobile station **30**, it is possible to cause a retransmission procedure in accordance with the synchronous HARQ system supported by LTE to be performed for the mobile station **30** (an LTE terminal). That is, it is possible to maintain compatibility (backward compatibility) with the mobile station **30** which is an LTE terminal.

Furthermore, the wireless resources for retransmission which the relay station **20** allocates to the mobile station **30** may be determined in consideration of the communication environment of the cell of the relay station **20**. Thereby, even if the relay station **20** intervenes between the base station **10** and the mobile station **30**, it is possible to cause appropriate data retransmission to be executed.

<Downlink Communication>

In the case of downlink communication also, the method applied to uplink communication is applied. That is, the base station **10** performs scheduling (for example, the SPS) for initial transmission of data as well as management of wireless resources for initial transmission. On the other hand, scheduling for retransmission of data is performed by the relay station **20**, and wireless resources used for retransmission of data are managed by the relay station **20**.

FIG. **4** is a diagram illustrating an example of HARQ timing in downlink communication in the embodiment. FIG. **4** illustrates an example of a case that data is transmitted from the base station (DeNB) **10** to the mobile station (UE) **30** via the relay station (RN) **20**.

In the example illustrated in FIG. **4**, the base station **10** transmits data to the mobile station **30** every ten sub-frames in accordance with the SPS. The base station **10** transmits data (data **1**) to the relay station **20** by a wireless resource for initial transmission allocated by the base station **10**, that is, at a sub-frame number "0" between the relay station and the base station (the Un interface). The relay station **20** transfers the data **1** to the mobile station **30** at a sub-frame number "4" (a sub-frame number "0" between the mobile station and the relay station) after elapse of 4 ms.

The mobile station **30** returns a confirmation response (ACK or NACK) to the relay station **20** at a transmission timing in accordance with the asynchronous HARQ system, that is, at a sub-frame number "4" 4 ms after the sub-frame number "0" in accordance with scheduling performed by the relay station **20**.

Thus, the mobile station **30** returns a confirmation response message to the relay station **20** at the sub-frame number "4" after elapse of 4 ms in accordance with the asynchronous HARQ system. In the example illustrated in FIG. **4**, a NACK message indicating failure in reception is returned to the relay station **20**.

Then, the relay station **20** retransmits the data **1** to the mobile station **30** at an arbitrary timing, at a sub-frame number "8" in the example in FIG. **4**, in accordance with the asynchronous HARQ system. The base station **10** transmits the next data (data **2**) to the relay station **20** at a sub-frame number "10." The relay station **20** transmits a confirmation response message (HARQ ACK) after 4 ms as well as transmitting the data **2** to the mobile station **30**, in accordance with the asynchronous HARQ system.

The mobile station **30** transmits a confirmation response message (ACK) to the retransmitted data **1** at a sub-frame number "12" and transmits a confirmation response message (ACK) to the data **2** at a sub-frame number "14," in accordance with the asynchronous HARQ system.

According to the above operation, by wireless resources for initial transmission being managed by the base station **10**, it is possible to avoid medium- or long-term interference due to simultaneous use of the same wireless resources by the base station **10** and the relay station **20**, similarly to the case of uplink communication. On the other hand, by wireless resources for retransmission being managed by the relay station **20**, it is possible to maintain backward compatibility with regard to HARQ timing. That is, it is possible to return an HARQ feedback (a confirmation response message) in accordance with the asynchronous HARQ system to the base station **10**.

Furthermore, it is possible to allocate the wireless resources for retransmission in consideration of the communication environment of the cell under the relay station **20**.

As illustrated in FIG. **4**, when retransmission of the data **1** from the relay station **20** to the mobile station **30** is successful, HARQ ACK indicating the success in the retransmission is returned from the mobile station **30** to the relay station **20**. However, even if receiving HARQ ACK, the relay station **20** does not relay HARQ ACK to the base station **10**. Thereby, it is possible to prevent the base station **10** from receiving an HARQ feedback (a confirmation response message) at an unexpected timing.

Furthermore, as illustrated in FIG. **4**, when receiving the confirmation response message (HARQ ACK) indicating success in reception of the data **1**, the base station **10** transmits the next data **2** on the assumption that the transmission of the data **1** to the mobile station **30** is successful, irrespective of whether or not data retransmission has occurred between the relay station **20** and the mobile station **30**. By an appropriate retransmission procedure being performed between the mobile station **30** and the relay station **20** in this way in the manner described above, it is possible for the mobile station **30** to receive the data **1** and for the base station **10** to receive the confirmation response message at a timing determined in advance.

<Method for Setting Cooperation Control>

In the description above, HARQ retransmission control based on cooperation control for wireless resource allocation between the base station **10** and the relay station **20** in each of the cases of uplink communication and down link communication has been explained. Next, a method for realizing the cooperation control will be described.

In this embodiment, a method for the base station **10** setting wireless resources for the Uu interface at the time of setup of the relay station **20** will be illustrated.

FIG. **5** is a diagram illustrating an example of a procedure for setting of wireless resources for the Uu interface by the base station **10** in the embodiment. In FIG. **5**, the base station **10** and the relay stations **20** are implemented with an application part (AP). As the AP, for example, X1AP provided in LTE may be illustrated as an example. The AP is not limited to X1AP, and it is possible to provide a new AP in accordance with LTE-A. In short, any protocol is possible if the protocol is the top layer (application) which performs various controls of a wireless link between the base station **10** and the relay station **20**.

In the procedure in FIG. **5**, the relay station **20** sends RRC Connection Request to the base station **10** at the RRC layer first (S**1**). The base station **10** returns RRC Connection Setup to the relay station **20** (S**2**). Then, the relay station **20** returns RRC Connection Setup Complete to the base station **10** (S**3**). The above communications of steps S**1** to S**3** are a procedure for setting up the relay station **20**.

Next, the base station **10** transmits an AP message request (a request to allocate wireless resources), which is a message at the AP layer, to the relay stations **20** (S**4**) and performs setting of Uu RRC (wireless resources for the Uu interface). That is, the base station **10** specifies allocation of wireless resources (SPS resources) to be used by the relay stations **20** which has been set up, for initial transmission of data for a medium- or long-term period, and notifies the relay station **20** of information about the wireless resources.

For example, the base station **10** may use a Radio Resource Configuration Dedicated message (FIG. **6**) provided in LTE to perform setting of wireless resources related to the SPS for the relay stations **20** using control information called sps-Config (FIG. **7**) included in the Radio Resource Configuration Dedicated message. However, a message different from the Radio Resource Configuration Dedicated message may be applied to setting of the wireless resources. When receiving the Radio Resource Configuration Dedicated message, the relay station performs SPS setting of wireless resources for the Un interface in accordance with the contents provided in sps-Config, and returns a response message (an AP message response) when the setting is completed (S**5**).

After that, when the mobile station **30** connects to the relay station **20**, the relay station **20** allocates wireless resources for initial transmission allocated by the base station **10** to the mobile station **30** using an RRC Connection Reconfiguration message (an allocation request message) (S**6**). The RRC Connection Reconfiguration message includes the above-described Radio Resource Configuration Dedicated message which includes sps-Config, and wireless resources allocation based on the SPS performed by the base station **10** is performed for the mobile station **30**.

The mobile station **30** performs setting of a transmission timing and wireless resources in accordance with the allocation request (S**6**), and returns a response message (RRC Connection Reconfiguration Complete) (S**7**).

In this way, the relay station **20** may allocate the wireless resources for initial transmission determined by the base station **10** to the mobile station **30**.

<Configuration of Base Station Apparatus>

Next, a configuration example of a base station apparatus **10**A which functions as the base station **10** illustrated in FIG. **1** will be described. FIG. **8** is a diagram illustrating the configuration example of the base station apparatus **10**A. In FIG. **8**, the base station apparatus **10**A is provided with a transmission/reception antenna **11**, a transmission/reception unit (transmitter/receiver) **12** connected with the transmission/reception antenna **11**, a scheduler section (scheduler) **13** (a first scheduler) connected with the transmission/reception unit **13**, an interface unit (interface) **14** with an upper station, and a control unit (controller) **15** connected with the transmission/reception unit **12**, the scheduler section **13** and the interface unit **14**.

The control unit **15** is provided with functions such as a wireless resource manager (SPS resource manager) **16** (a first manager), a scheduler control unit (scheduler controller) **17**, an interface manager (application: AP) **18** and the like. The control unit **15** may be realized by a processor, and the control unit **15** may be adapted to execute a control operation by operating in accordance with a program.

The interface unit **14** is in charge of the top protocol layer and performs transmission/reception of data. The scheduler section **13** accumulates received data into a buffer (which is provided for the scheduler section **13**) once and executes

scheduling of the data in accordance with an instruction of the control unit **15**. The transmission/reception unit **12** performs wireless transmission/reception of data.

The control unit **15** executes various controls related to wireless communication. The scheduler control unit **17** determines a scheduling algorithm and controls the order of data transmission. Therefore, the schedule control unit **17** controls the scheduler section **13**, and, when a data error (failure in decoding) occurs, executes retransmission of data.

The interface manager (application section) **18** is the top protocol layer implemented on the base station apparatus **10**A, and it manages exchange of control information with other stations. The management is executed by exchanging AP messages.

The wireless resource manager (SPS resource manager) **16** performs management and control of wireless resources. That is, the wireless resource manager **16** performs management and control of wireless resources related to the SPS.

FIG. **9** is a flowchart illustrating an operation example of the base station apparatus **10**A at the time of setup of the relay station described in FIG. **5**. When setup of the relay station **20** is started, the control unit **15** of the base station apparatus **10**A receives RRC Connection Request from the relay station **20** first (step S**001**). Next, the control unit **15** transmits RRC Connection Setup to the relay station **20** (step S**002**). Next, the control unit **15** receives RRC Connection Setup Complete (step S**003**). Next, the wireless resource manager **16** specifies SPS resources by an AP message and notifies the relay stations **20** thereof (step S**004**). After that, the wireless resource manager **16** receives an AP message response from the relay station **20** (step S**005**) and ends the process.

FIG. **10** is a flowchart illustrating an operation example (an uplink SPS communication process) of the base station apparatus **10**A at the time of uplink SPS communication described in FIG. **3**. In FIG. **10**, when the process is started, the transmission/reception section judges whether uplink data has been received (uplink communication data) or not (step S**101**). When uplink data has not been received, the process ends. In comparison, when uplink data has been received, the schedule control unit **17** judges whether the reception of the uplink data has failed or not (step S**102**). When the reception of the uplink data has been failed, the wireless resource manager **16** sets wireless resources for retransmission (step S**103**), and the scheduler section **13** returns NACK (step S**105**). In comparison, when the reception of the uplink data has not failed (successful), the scheduler section **13** returns ACK (step S**104**). After steps S**104** and S**105** end, the uplink SPS communication process ends.

FIG. **11** is a flowchart illustrating an operation example (a downlink SPS communication process) of the base station apparatus **10**A at the time of downlink SPS communication described in FIG. **4**. In FIG. **11**, when the process is started, the transmission/reception section judges whether downlink data (downlink communication data) has been received or not (step S**111**). When downlink data has not been received, the process ends. In comparison, when downlink data has been received, the schedule control unit **17** judges whether the reception of the downlink data has failed or not (step S**112**). When the reception of the downlink data has failed, the wireless resource manager **16** sets wireless resources for retransmission (step S**113**), and the scheduler section **13** returns NACK (step S**115**). In comparison, when the reception of the downlink data has not failed (successful), the scheduler section **13** returns ACK (step S**104**). After steps S**114** and S**115** end, the downlink SPS communication process ends.

<Configuration of Relay Station Apparatus>

Next, a configuration example of a relay station apparatus **20**A which functions as the relay station **20** illustrated in FIG. **1** will be described. FIG. **12** is a diagram illustrating the configuration example of the relay station apparatus **20**A. In FIG. **12**, the relay station apparatus **20**A is provided with a user-side (terminal-side) transmission/reception antenna **21**A, a network-side (base-station-side) transmission/reception antenna **21**B, a transmitter/receiver **22**A connected with the transmission/reception antenna **21**A, and a transmitter/receiver **22**B connected with the transmission/reception antenna **21**B. The relay station apparatus **20**A is also provided with a scheduler **23** (second scheduler) connected with the transmitter/receiver **22**A, an interface (interface circuit) **24**, and a control unit (controller) **25** connected with the transmitter/receiver **22**A, the scheduler section **23** and the interface section **24**.

The control unit **25** is provided with a wireless resource manager (SPS initial transmission manager) **26**A, a wireless resource manager (SPS retransmission manager) **26**B (second manager), a schedule control unit **27** and an interface manager (application section: AP) **28**.

The wireless resource manager (SPS initial transmission manager) **26**A performs management and control of wireless resources. Especially in the case of the SPS, it performs management and control of wireless resources for initial transmission. The wireless resource manager (SPS retransmission manager) **26**B performs management and control of wireless resources. Especially in the case of the SPS, it performs management and control of wireless resources for retransmission. Each of the blocks except the wireless resource control units **26**A and **26**B have functions almost similar to those of the blocks having the same names in the base station apparatus **10**A.

FIG. **13** is a flowchart illustrating an operation example (a setup process) of the relay station apparatus **20**A at the time of setup of the relay station **20**. In FIG. **13**, when the process is started, the control unit **25** transmits RRC Connection Request to the base station **10** (step S**201**).

Next, the control unit **25** receives RRC Connection Setup from the base station **10** (step S**202**). Next, the control unit **25** transmits RRC Connection Setup Complete to the base station **10** (step S**203**). Next, the wireless resource manager **26**A receives specification of SPS resources from the base station **10** by an AP message (step S**204**).

Next, the wireless resource manager **26**A transmits an AP message response to the base station **10** (step S**205**). Next, the control unit **15** specifies SPS resources for initial transmission to the mobile station **30** by RRC Connection Reconfiguration (step S**206**). After that, the control unit **15** receives Connection Reconfiguration Complete from the mobile station **30** (step S**207**) and ends the relay station setup process.

FIG. **14** is a flowchart illustrating an operation example (an uplink communication process) of the relay station **20** at the time of uplink SPS communication. When the process illustrated in FIG. **14** is started, the transmission/reception section **21**A judges whether uplink data has been received or not (step S**211**). When uplink data has not been received, the process ends.

When uplink data has been received, the schedule control unit **27** judges whether the reception of the uplink data has failed or not (step S**212**). When the reception of the uplink data has failed, the SPS retransmission manager **26**B notifies wireless resources for data retransmission (step S**213**), and the scheduler section **23** returns NACK to the mobile station **30** (step S**214**). After that, the process returns to step S**211**.

In comparison, when the reception of the uplink data has not failed, that is, the reception has succeeded, the scheduler section **23** returns ACK to the mobile station **30** (step S**215**).

After that, the transmission/reception section **22**B judges whether the uplink data has been transmitted or not (step S**216**). When uplink data has not been transmitted, the process ends. In comparison, when uplink data has been transmitted, the scheduler control unit **27** judges whether the transmission has failed or not (step S**217**).

When the transmission has failed, the wireless resource manager (SPS retransmission manager) **26**B sets wireless resources for retransmission for the mobile station **30** (step S**218**), and the scheduler control unit **27** returns NACK (step S**219**). In comparison, when the transmission has not failed, that is, the transmission has succeeded, the scheduler section **27** returns ACK. After steps S**219** and S**220** end, the uplink SPS communication process ends.

FIG. **15** is a flowchart illustrating an operation example (a downlink communication process) of the relay station **20** at the time of downlink SPS communication. When the process illustrated in FIG. **15** is started, the transmission/reception section **21**B judges whether downlink data has been received or not (step S**221**). When downlink data has not been received, the process ends.

When downlink data has been received, the scheduler control unit **27** judges whether the reception of the downlink data has failed or not (step S**222**). When the reception of the downlink data has failed, the wireless resource manager (SPS retransmission manager) **26**B sets wireless resources for data retransmission (step S**213**), and the scheduler section **23** returns NACK to the base station **10** (step S**224**). After that, the process returns to step S**221**.

In comparison, when the reception of the downlink data has not failed, that is, the reception has succeeded, the scheduler section **23** returns ACK to the base station **10** (step S**225**). After that, the transmission/reception section **22**A judges whether the downlink data has been transmitted or not (step S**226**). When downlink data has not been transmitted, the process ends. In comparison, when downlink data has been transmitted, the scheduler control unit **27** judges whether the transmission has failed or not (step S**227**).

When the transmission has failed, the wireless resource manager (SPS retransmission manager) **26**B sets wireless resources for retransmission for the base station **10** (step S**228**), and the scheduler control unit **27** returns NACK (step S**229**). In comparison, when the transmission has not failed, that is, the transmission has succeeded, the scheduler section **27** returns ACK to the base station **10**. After steps S**229** and S**230** end, the downlink SPS communication process ends.

<Configuration of Mobile Station Apparatus>

Next, a configuration example of a mobile station apparatus **30**A which functions as the mobile station **30** illustrated in FIG. **1** will be described. FIG. **16** is a diagram illustrating the configuration example of the mobile station apparatus **30**A. In FIG. **16**, the mobile station apparatus **30**A is provided with a transmission/reception antenna **31**, a transmission/reception section **32** connected with the transmission/reception antenna **31**, and a control unit (controller) **33** connected with the transmission/reception section **32**. The control unit **33** is provided with a wireless resource manager (SPS resource manager) **34**.

The transmission/reception section **32** performs wireless transmission/reception of data. The control unit **33** executes various controls related to wireless communication. There are a case of being controlled directly by the relay station **20** as illustrated by the solid arrow in FIG. **16**, and a case of being controlled indirectly by the base station **10** as illustrated by a broken-line arrow. However, which of the base station **10** and the relay station **20** controls is not noticed.

The wireless resource manager (SPS resource manager) performs management control of wireless resources. Especially in the case where SPS scheduling of wireless resources is performed, management control of wireless resources for retransmission is performed.

FIG. **17** is a flowchart illustrating an operation example (a setup process) of the mobile station apparatus **30**A at the time of setup of the relay station **20**. When the process illustrated in FIG. **17** is started, the control unit **33** receives SPS resources for initial transmission by RRC Connection Reconfiguration (step S**301**). When the SPS resources for initial transmission are secured in accordance with RRC Connection Reconfiguration, the control unit **33** transmits RRC Connection Reconfiguration Complete (step S**302**) and ends the process.

FIG. **18** is a flowchart illustrating an operation example (an uplink SPS communication process) of the relay station apparatus **30**A at the time of uplink SPS communication. When the process illustrated in FIG. **18** is started, the transmission/reception section **32** judges whether uplink data has been transmitted or not (step S**311**). When uplink data has not been transmitted, the process ends.

When uplink data has been transmitted, the control unit **33** judges whether the transmission has failed or not (step S**312**). When the transmission has failed, the wireless resource manager **34** performs setting of retransmission resources (step S**313**). After that, the control unit **33** issues a retransmission instruction, and the transmission/reception section **32** retransmits the uplink data. In comparison, when the transmission has not failed, that is, the transmission has succeeded, the control unit **33** instructs initial transmission of the next uplink data (step S**315**), and the transmission/reception section **32** transmits the next uplink data. When steps S**314** and S**315** end, the uplink SPS communication process ends.

FIG. **19** is a flowchart illustrating an operation example (a downlink SPS communication process) of the mobile station apparatus **30**A at the time of downlink SPS communication. When the process illustrated in FIG. **19** is started, the transmission/reception section **32** judges whether downlink data has been received or not (step S**321**). When downlink data has not been received, the process ends.

When downlink data has been received, the control unit **33** judges whether the reception of the downlink data has failed or not (step S**322**). When the reception has failed, the control unit **33** instructs transmission of NACK (step S**323**), and the transmission/reception section **32** transmits NACK. After that, the wireless resource manager **34** performs setting of wireless resources for receiving the retransmitted data.

In comparison, when the reception has not failed, that is, the reception has succeeded, the control unit **33** instructs transmission of ACK (step S**325**), and the transmission/reception section **32** transmits ACK. When processing of step S**324** or S**325** ends, the downlink SPS communication process ends.

Each of the blocks of the base station apparatus **10**A, the relay station apparatus **20**A and the mobile station apparatus **30**A described above may be realized by dedicated or general-purpose hardware. Alternatively, a part or all of functions realized by each block may be realized by a processor, such as a CPU and a DSP, executing a program stored in a storage device such as a memory.

According to the embodiment, it is possible to execute an appropriate retransmission procedure even when a relay station intervenes in communication between a mobile station and a base station.

All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A mobile communication system, comprising:

a base station; and

a relay station to relay data transmitted/received between the base station and a mobile station,

the base station including:

a first scheduler configured to perform scheduling of initial transmission of the data transmitted/received between the base station and the mobile station via the relay station; and

a first manager configured to manage predetermined wireless resources which are periodically used, as wireless resources used for the initial transmission of the data; and

the relay station including:

a second scheduler configured to perform scheduling of transmission of a message for confirming necessity of retransmission of the data and retransmission of the data; and

a second manager configured to manage wireless resources used for the transmission of the message and the retransmission of the data.

2. The mobile communication system according to claim **1**, wherein the relay station inhibits a message indicating success of reception of the retransmitted data, which is received from the mobile station, from being relayed to the base station.

3. The mobile communication system according to claim **1**, wherein, when receiving a message indicating success of reception by the relay station in response to the data initially transmitted to the relay station, the base station regards transmission of the data to the mobile station as having succeeded, irrespective of whether retransmission of the data has occurred between the relay station and the mobile station.

4. The mobile communication system according to claim **1**, wherein the predetermined wireless resources which are periodically used are wireless resources used in accordance with Semi-persistent Scheduling in Long Term Evolution.

5. A mobile station for transmitting and receiving data to and from a base station via a relay station, the mobile station comprising:

a transmitter/receiver configured to transmit and receive data initially transmitted in accordance with scheduling of initial transmission of the data using predetermined wireless resources which are managed by the base station and periodically used; and

a controller configured to perform control for, in accordance with scheduling of transmission of a message for confirming necessity of retransmission of the data and the retransmission of the data with the use of wireless resources managed by the relay station, transmitting and receiving the message and the retransmitted data.

6. A relay station to relay data transmitted/received between a base station and a mobile station, the relay station comprising:

a transmitter/receiver configured to transmit/receive the data initially transmitted in accordance with scheduling of initial transmission of the data using predetermined wireless resources which are managed by the base station and periodically used; and

a controller configured to control, in accordance with scheduling of transmission of a message for judging necessity of retransmission of the data and the retransmission of the data with the use of wireless resources managed by the relay station, the transmission of the message and the retransmission of the data,

wherein the controller inhibits the message received from one of the base station and the mobile station from being relayed to the other.

7. A schedule method in a mobile communication system comprising a base station and a relay station relaying data transmitted/received between the base station and a mobile station, the method comprising:

the base station performing scheduling of initial transmission of the data using predetermined wireless resources which are managed by the base station and periodically used; and

the relay station performing scheduling of transmission of a message confirming necessity of retransmission of the data and the retransmission of the data with the use of wireless resources managed by the relay station.

8. The scheduling method of the mobile communication system according to claim **7**, wherein the relay station inhibits a message indicating success of reception of the retransmitted data, which is received from the mobile station, from being relayed to the base station.

9. The scheduling method of the mobile communication system according to claim **7**, wherein, when receiving a message indicating success of reception by the relay station in response to the data initially transmitted to the relay station, the base station regards transmission of the data to the mobile station as having succeeded, irrespective of whether retransmission of the data has occurred between the relay station and the mobile station.

10. The scheduling method of the mobile communication system according to claim **7**, wherein the predetermined wireless resources which are periodically used are wireless resources used in accordance with Semi-persistent Scheduling in Long Term Evolution.

11. A data transmission/reception method of a mobile station for transmitting and receiving data to and from a base station via a relay station, the method comprising:

transmitting and receiving data initially transmitted in accordance with scheduling of initial transmission of the data using predetermined wireless resources which are managed by the base station and periodically used; and

in accordance with scheduling of transmission of a message for confirming necessity of retransmission of the data and the retransmission of the data with the use of wireless resources managed by the relay station, transmitting and receiving the message and the retransmitted data.

12. A data transmission/reception method of a relay station relaying data transmitted/received between a base station and a mobile station, the method comprising:

transmitting/receiving data initially transmitted in accordance with scheduling of initial transmission of the data using predetermined wireless resources which are managed by the base station and periodically used;

performing, in accordance with scheduling of transmission of a message for judging necessity of retransmission of the data and the retransmission of the data with the use of

wireless resources managed by the relay station, the transmission of the message and the retransmission of the data; and

inhibiting the message received from one of the base station and the mobile station from being relayed to the other.

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